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MODERN PLANT NUMBER

MID-SEPTEMBER, 1937
IN TWO SECTIONS

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For Capacities from 150,000 lbs. of steam per hour up
THE RILEY HIGH CAPACITY HIGH EFFICIENCY STEAM GENERATING UNIT

RILEY HAS MORE THAN KEPT PACE

with recent advances in boiler design

...that is why there continues to be such a definite SWING to **RILEY** equipment

The engineering profession is quite generally talking of the tremendous progress Riley has made during the past five or six years in the boiler industry, both as to design and number of units installed. Riley has very definitely more than kept pace with the rapid advances made in boiler design and construction. Riley units today are modern, highly efficient units with plus values which assure entirely satisfactory results, often exceeding the expectations of the purchaser.

Sales volume, after all, is the best barometer of the progress of a company in an industry. Riley sales started a decided climb when the swing to Riley started in 1931, far before any general business improvement. The fact that sales each year have increased substantially beyond that of the boom period of 1929 establishes the general acceptance of modern Riley units and the unusual results being obtained from recent Riley installations.

A visit to recent Riley installations will clearly explain why there has been such a decided swing to Riley. You owe it to yourself and your company to thoroughly investigate Riley equipment when considering boiler plant improvements.

LIST OF A FEW RECENT INSTALLATIONS

RILEY

STEAM GENERATING UNITS

High Capacity High Efficiency Units

Central Illinois Light Co., Peoria, Ill.
1—300,000 lbs./hr.—900 lbs.
Lynn Gas & Electric Co., Lynn, Mass.
1—205,000 lbs./hr.—450 lbs.
Otter Tail Power Co., Wahpeton, N. D.
1—130,000 lbs./hr.—600 lbs.
Holyoke Water Power Co., Holyoke, Mass.
1—170,000 lbs./hr.—675 lbs.
Fort Bend Utilities, Sugarland, Texas
1—160,000 lbs./hr.—450 lbs.
W. Va. Pulp & Paper Co., Covington, Va.
2—375,000 lbs./hr. each—600 lbs.
W. Va. Pulp & Paper Co., Luke, Md.
2—375,000 lbs./hr. each—650 lbs.
W. Va. Pulp & Paper Co., Charleston, S. C.
2—225,000 lbs./hr. each—600 lbs.
W. Va. Pulp & Paper Co., Williamsburg, Pa.
2—71,500 lbs./hr. each—600 lbs.
Large Eastern Oil Refinery
2—300,000 lbs./hr. each—650 lbs.
Humble Oil & Refining Co., Baytown, Texas
1—350,000 lbs./hr.—675 lbs.
Standard Oil Co. of Calif., Richmond, Calif.
3—125,000 lbs./hr. each—900 lbs.
Bahrein Petroleum Co., Persian Gulf
2—106,000 lbs./hr. each—600 lbs.
Celanese Corp. of Amer., Cumberland, Md.
2—200,000 lbs./hr. each—475 lbs.
Libby Owens Ford Glass Co., Rossford, O.
1—175,000 lbs./hr.—450 lbs.
Publicker Comm. Alcohol Co., Phila., Pa.
1—275,000 lbs./hr.—475 lbs.
MacAndrews & Forbes Co., Camden, N. J.
2—100,000 lbs./hr. each—465 lbs.
Great Western Sugar Co., Billings, Mont.
3—125,000 lbs./hr. each—160 lbs.
Godchaux Sugars, Reserve, La.
1—100,000 lbs./hr.—475 lbs.
U. S. Military Academy, West Point, N. Y.
2—100,000 lbs./hr. each—160 lbs.

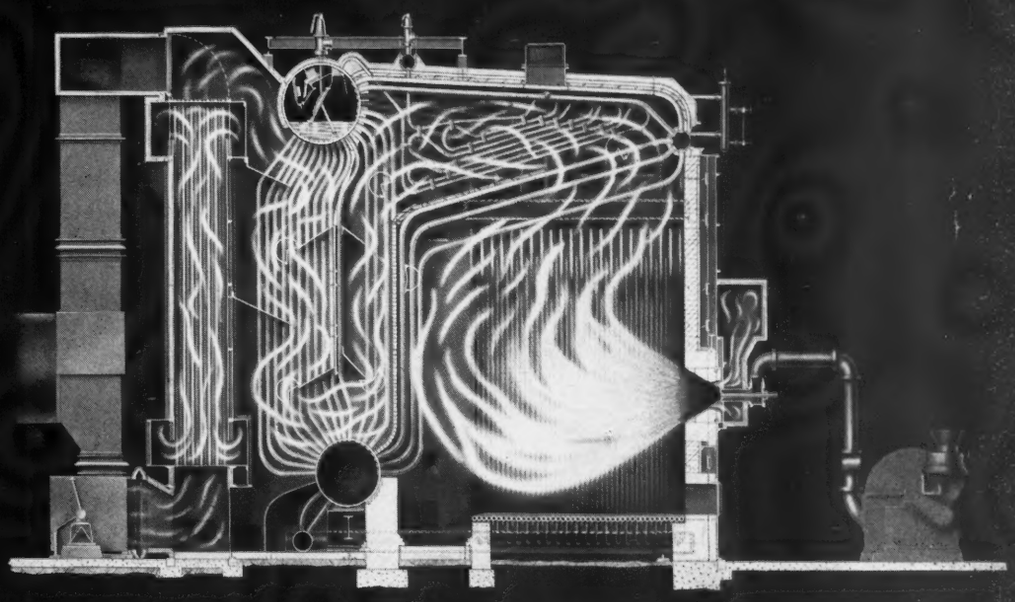
Riley "RP" Units

Guide Lamp Co., General Motors Corp., Anderson, Ind.
1—50,000 lbs./hr.—275 lbs.
Bemis Bag Co., Peoria, Ill.
1—70,000 lbs./hr.—275 lbs.
Newport Electric Co., Newport, R. I.
2—60,000 lbs./hr. each—275 lbs.
General Aniline Co., Rensselaer, N. Y.
1—80,000 lbs./hr.—250 lbs.
Riverside Metal Co., Riverside, N. J.
1—65,000 lbs./hr.—450 lbs.
Wheeling Steel Co., Wheeling, W. Va.
1—100,000 lbs./hr.—660 lbs.
Central Ohio Pr. & Lt. Co., Findlay, Ohio
2—60,000 lbs./hr. each—450 lbs.
Hartford City Paper Co., Hartford City, Ind.
1—55,000 lbs./hr.—350 lbs.
Lewiston Bleachery, Lewiston, Me.
1—70,000 lbs./hr.—450 lbs.
Hellwig Silk Dyeing Co., Philadelphia, Pa.
1—100,000 lbs./hr.—475 lbs.
Great Lakes Steel Corp., Ecorse, Mich.
2—75,000 lbs./hr. each—450 lbs.
Natrona Power & Light Co., Natrona, Pa.
1—90,000 lbs./hr. each—450 lbs.
S. J. Brisban Co., Colombia, S. America
1—36,000 lbs./hr.—425 lbs.
Winchester Repeating Arms Co., New Haven, Conn.
2—75,000 lbs./hr.—each725 lbs.
Western Cartridge Co., E. Alton, Ill.
2—75,000 lbs./hr. each—725 lbs.
American Bridge Co., Trenton, N. J.
2—35,000 lbs./hr. each—275 lbs.
Port Huron Sulphite & Paper Co., Port Huron, Mich.
1—80,000 lbs./hr.—675 lbs.
Barrett Co., Frankfort, Philadelphia, Pa.
1—80,000 lbs./hr.—450 lbs.

Riley "RO" Units

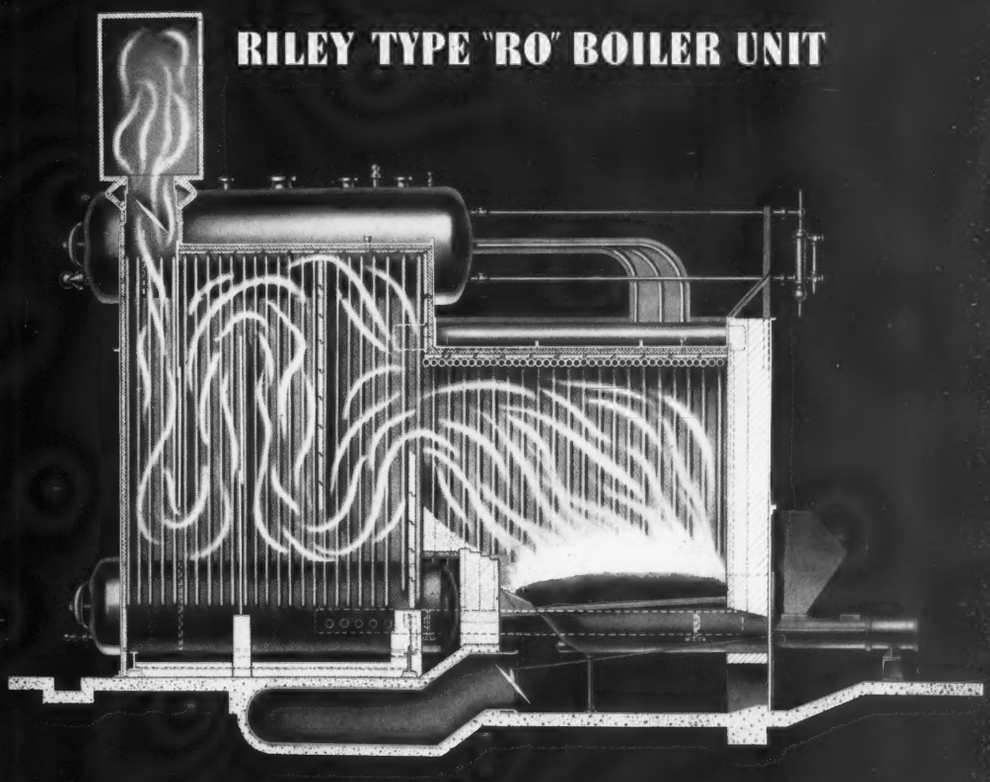
Pet Milk Co., Coldwater, Ohio
1—20,000 lbs./hr.
Pet Milk Co., Delta, Ohio
1—20,000 lbs./hr.
Pet Milk Co., Weyland, Mich.
1—20,000 lbs./hr.
Seneca Knitting Co., Seneca Falls, N. Y.
1—15,000 lbs./hr.
C. G. Conn Co., Elkhart, Ind.
1—30,000 lbs./hr.
Seegar Refrigerating Co., St. Paul, Minn.
1—25,000 lbs./hr.
Hooker Paint & Glass Co., Chicago, Ill.
2—7,500 lbs./hr. each

RILEY TYPE "RP" BOILER UNIT



For Capacities between 40,000 and 150,000 lbs. per hour
THE RILEY TYPE "RP" STEAM GENERATING UNIT

RILEY TYPE "RO" BOILER UNIT



For Capacities between 7500 and 40,000 lbs. per hour
THE RILEY TYPE "RO" STEAM GENERATING UNIT

COMPLETE STEAM GENERATING UNIT

RILEY

STOKER CORPORATION
WORCESTER, MASSACHUSETTS

BOILERS - SUPERHEATERS - AIR HEATERS - ECONOMIZERS - PULVERIZERS - BURNERS - STOKERS
WATER-COOLED FURNACES - STEEL CLAD SETTINGS

Boston New York Philadelphia Pittsburgh Buffalo Cleveland Detroit
Tacoma Baltimore St. Louis Cincinnati Houston Chicago
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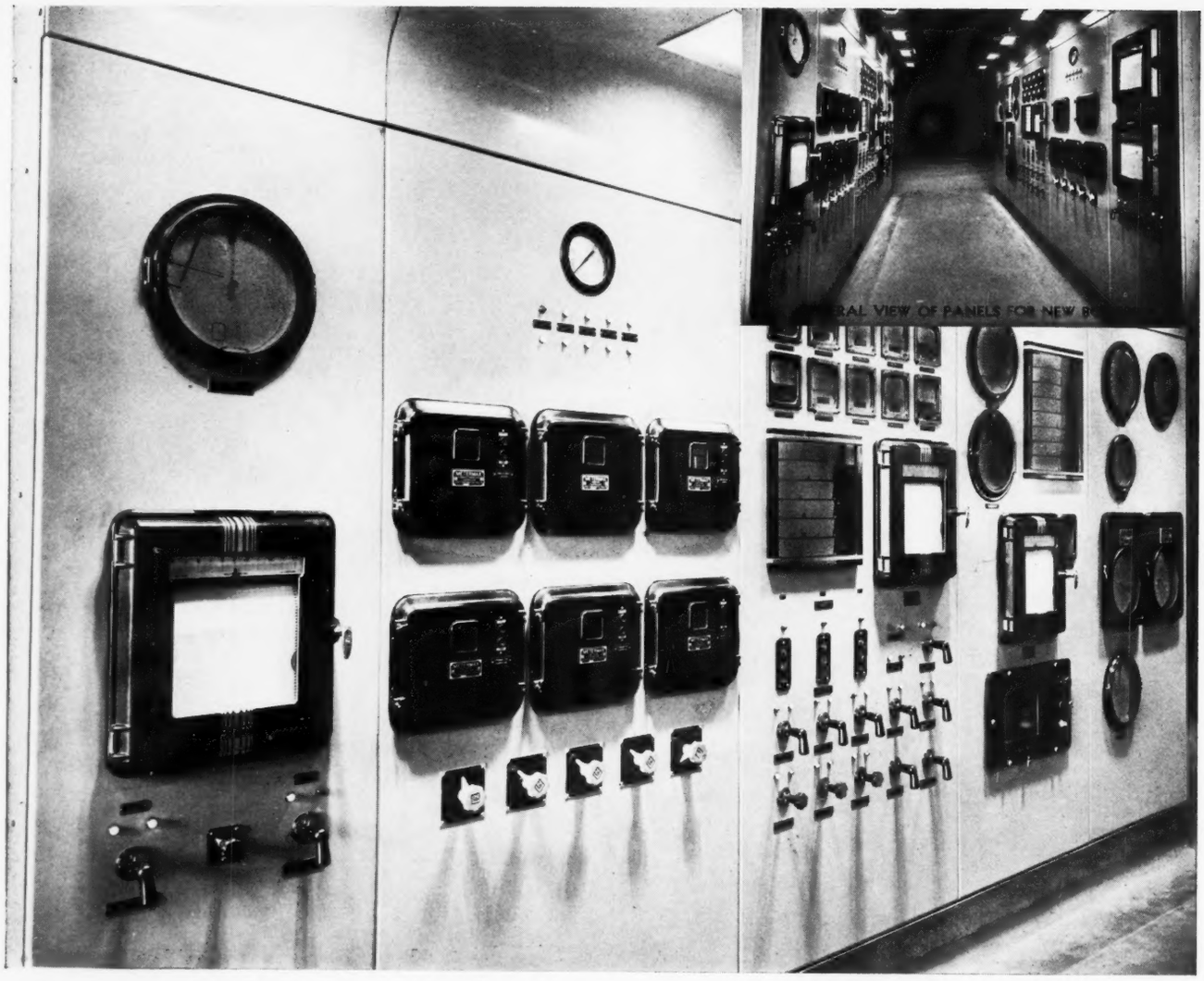

Micromax
Superheat Controller

Metermax
Combustion Controllers

Superheat At Millers Ford under MICROMAX CONTROL

Superheat temperature will be under Micromax automatic control when these boiler panels go into service in the "topping" extension at Millers Ford, Ohio. Instrumentation for the Control involves only three Micromax Strip-Chart Recording Controllers.

Two of these (one on each boiler) regulate the temperature of superheat by directing the action of drive-units on by-pass dampers. The temperature for which the Controllers are set must be such that the turbine exhaust temperature stays within certain limits, and the necessary adjustment is maintained by a third Micromax Controller, which measures the exhaust temperature and re-sets the two superheat Controllers as may be necessary.

Control of combustion is secured with Metermax Unit Combustion Control. Employing air-loaded control instruments and electric drive-units, Metermax offers extreme dependability with easy installation and low maintenance.

Other L & N Equipment at Millers Ford Station

In addition to Micromax Superheat Control and Metermax Unit Combustion Control, these boiler panels have Micromax Recorders for temperatures of flue gas and preheater air at various points, air from pulverizers, and for feedwater. The Station also uses Micromax Recorders for stator and field temperatures.

LEEDS & NORTHRUP COMPANY, 4910 STENTON AVE., PHILA., PA.

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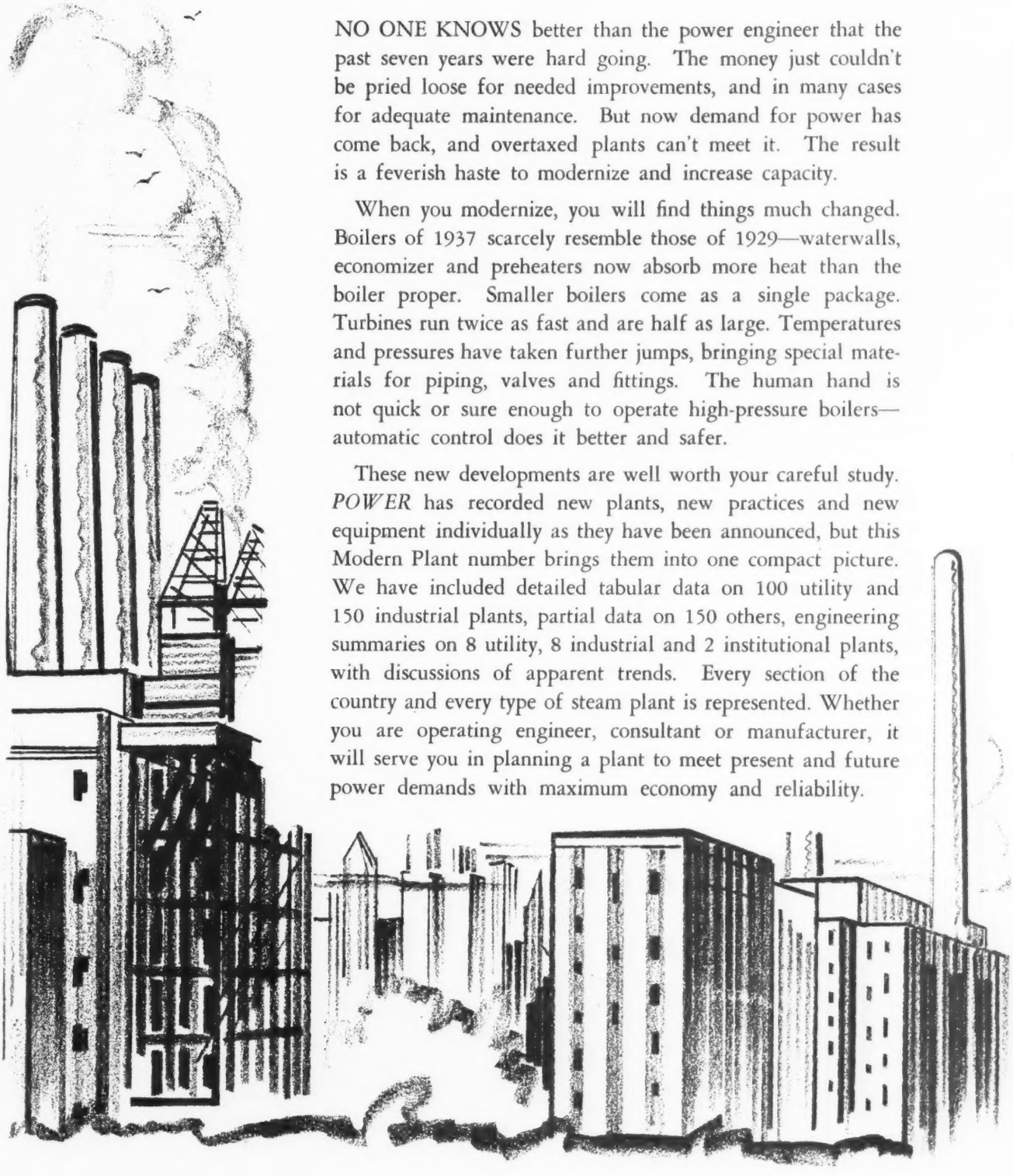
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

J-N33A-163(1)

Power

A McGRAW-HILL PUBLICATION — ESTABLISHED 1882 — PHILIP W. SWAIN, EDITOR

MODERN PLANT NUMBER



NO ONE KNOWS better than the power engineer that the past seven years were hard going. The money just couldn't be pried loose for needed improvements, and in many cases for adequate maintenance. But now demand for power has come back, and overtaxed plants can't meet it. The result is a feverish haste to modernize and increase capacity.

When you modernize, you will find things much changed. Boilers of 1937 scarcely resemble those of 1929—waterwalls, economizer and preheaters now absorb more heat than the boiler proper. Smaller boilers come as a single package. Turbines run twice as fast and are half as large. Temperatures and pressures have taken further jumps, bringing special materials for piping, valves and fittings. The human hand is not quick or sure enough to operate high-pressure boilers—automatic control does it better and safer.

These new developments are well worth your careful study. *POWER* has recorded new plants, new practices and new equipment individually as they have been announced, but this Modern Plant number brings them into one compact picture. We have included detailed tabular data on 100 utility and 150 industrial plants, partial data on 150 others, engineering summaries on 8 utility, 8 industrial and 2 institutional plants, with discussions of apparent trends. Every section of the country and every type of steam plant is represented. Whether you are operating engineer, consultant or manufacturer, it will serve you in planning a plant to meet present and future power demands with maximum economy and reliability.

INDUSTRIAL TRENDS

More high-pressure plants . . . Many tops under 1000 lb. . . . Electric loads growing faster than steam . . . Scientific feed treatment . . . Debunked coal buying . . . Water-cooled stokers . . . More waterwalls . . . More dust elimination . . . Lots of welding

ON THE twenty pages immediately following this article are described eight industrial and two institutional power installations now under construction or put into operation since Jan. 1, 1936.

The plants thus featured are not necessarily the "best" plants of 1936 and 1937. Any such classification would be presumptuous. They are presented merely as excellent examples of modern design, covering a wide range of industries, conditions and sizes. Steam pressures range from 150 to 1,400 lb.; temperatures from 415 to 925 F. Tops, additions, new plants, condensing and non-condensing turbines, and engines are included.

These concise plant descriptions, tables of equipment, flow diagrams and cross-sections of boiler units will be useful to all industrial engineers contemplating additional capacity. They will also find useful data in the elaborate tabulation of 500 modern plants in Section II and on pages 587 and 588. Out of this great mass of new installations, any reader can find several in his own industry and similar to his own in size, type of load and other conditions. He can then compare the solutions of various designs with his own.

No data are of greater interest right now than steam pressures and temperatures. Here industrial plants do not, in general, follow the central-station lead, because their conditions are entirely different. Backpressure installations far exceed the condensing in number. Most condensing installations are bled heavily for process and heating. Higher backpressures permit lower steam temperatures for a given pressure. Thus, out of all the industrials tabulated, only four have a steam temperature above 760 F. The accompanying charts plot steam pressure against temperature for the tabulated industrial plants (omitting institutional and engine-powered plants).

So much for the articles and tables. To make the best use of the remaining space, we have asked a group of experienced engineers to comment on present and future trends in the field of industrial power plants. The following statements are based in part on their answers and in part on the personal observations of the editors.

Load Trends

The ratio of power load to steam load is a fundamental consideration in the design of an industrial plant, profoundly affecting hookup and steam pressure in particular. Fundamental technical changes in the process industries are building up power load faster than the steam load. In paper plants, for example, more power is being used to produce the regular grade of paper or board, with progressively poorer raw materials. At the same time better heat application and better heat-transfer equipment are cutting the *relative* (not necessarily the *actual*) steam demand. This clearly points to an increasing demand for higher pressures in order to generate more by-product power per pound of steam. Even at that, most industrials will be able to meet their economic needs with pressures well under 600 lb.

Tops and Pressures

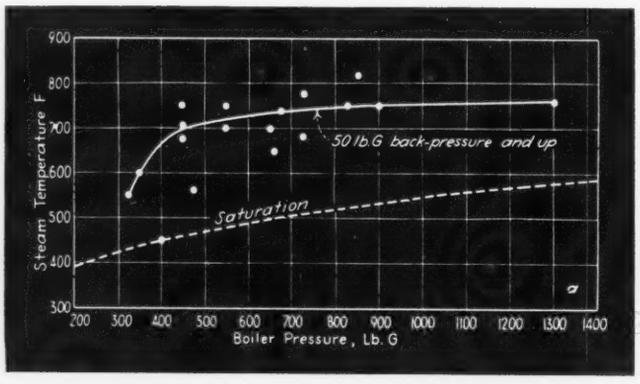
The "topping" of low-pressure industrial plants will continue much longer than with the utilities, because the plants suitable for topping are more numerous and also because of the load-ratio trend just noted. Moreover, industrial tops will be more varied in form and include many plants with three or four pressure levels—in short, "tops on tops." Utility tops almost always are for 1,200-lb. boiler pressure or higher. For the next few years, at least, most of the industrial tops will be for less than 1,000 lb.

Many of the industrials require from 50 to nearly 100% raw-feedwater makeup. With expert control of water softening and boiler-water conditions, 900-lb. steam has been proved workable with 100% makeup. Few owners are willing to venture higher without evaporators or further developments in water treatment. Not all would go even up to 900 lb. Pressures of 400 or 500 lb., with 100% makeup, chemically treated, are admittedly conservative, however.

Feedwater

Water treatment is still in a state of flux. Much is heard of colloidal treatment, for example, but little information is available in simple understandable terms. Zeolite treatment finds considerable favor in certain industries (e.g., textile) where zeolite-treated water is ideal for process work, and where the nature of the hardness and low cost of salt keeps operating cost within reason. In these, the factory water softener can also supply the boiler, with perhaps some additional treatment with sodium phosphate and sulphite. More commonly, the medium- and high-pressure jobs use hot lime-soda softeners for primary treatment, followed by filtering,

BOILER STEAM TEMPERATURE AND PRESSURE RELATIONSHIP



Turbines exhausting (a) at 50 lb. backpressure and up, (b) at 0 to 49 lb. backpressure, and (c) to condenser

deaeration and addition of phosphate to effect final conditioning of boiler water.

Many practical working methods of treating feedwater are available, but the field still needs men who can bring simplicity out of its overcomplication and recognizable truth out of its confusion of claims and counterclaims.

Fuel Selection

The industrial-power field is now awake to the need for combustion equipment that can handle a wide variety of coals, including poor coals, without much loss of capacity or efficiency and without excessive outages (as from tube slagging, clinkers, etc.).

Engineers of old plants, with obsolete equipment, must be shrewd buyers to get suitable coals without paying excessive premiums. It's no easy problem, and not one to be solved once and for all by a good set of coal specifications. Coal and firing are so complex that even the *honest* application of specification buying may not bring the desired results. Add the human element, and you have specifications not lived up to, analyses and sampling challenged, and general dissatisfaction.

Amid all this confusion, a light begins to dawn. An authoritative committee has been formed, representing many groups interested in the sale and purchase of coal. It is proposed that producers register their fuels with this committee and that the committee act as a clearing house for fuel information. Meanwhile, most engineers will continue to buy by test operation in their own boilers, with only partial dependence on specifications.

Stokers

Both pulverized fuel and stokers are widely used. In the new central-station installations, pulverized coal has a definite lead. The larger industrials give pulverized coal about an even break with the various types of stokers. In smaller plants stokers take a definite lead.

The stoker has been credited with a cleaner stack—important with easily damaged products and in urban districts. Pulverized-fuel, on the other hand, has been assumed to permit easier every-day maintenance of test efficiency and less trouble with poor fuels at high ratings. Moreover, the stoker has sometimes faced difficulties (clinkers and high maintenance) with an otherwise suitable degree of air preheat. This last situation has been completely changed by the perfection of the water-cooled stoker.

The trend towards water-cooled furnace walls continues unabated. Waterwalls are something more than a safe housing for hot furnaces; they supply heating surface that does far more work per pound of metal than any other in the steam-generating unit.

More than half of the new steam-generating units tabulated have either economizer or air heater or both. The typical high-pressure installation has both. Considering all types of plants, more air heaters than economizers are installed.

Coal and Ash Handling

The improvement of coal- and ash-handling equipment continues in detail rather than in radical changes. On the other hand, flue-gas cleaning is advancing rapidly. Few industrial plants use electrostatic precipitators, but many are using dry or wet dust separators of various types.

Instruments and Controls

Full-fledged combustion control, with all the gadgets, has not yet swept the industrial field, as it has that of central stations. Most of the big new industrial installations have complete controls, but smaller plants save first cost with compromises. It seems to be the consensus of opinion that the smaller plants should at least have the main control elements. For example, a pressure regulator controlling air and coal, a furnace-pressure control. An excess-pressure pump control is recognized as a logical way to reduce feed-pumping costs in high-pressure installations. Other commonly specified equipment includes feedwater regulators, coal scales, feedwater meters, steam meters, and an assortment of recording thermometers and pressure gages.

Welding

Welding is universally accepted; the only questions are where, how and how much. Welding costs little more than bolted flange joints for all but the smaller piping, if one allows for installation flexibility, easy covering, etc. Maintenance is much less. Welding is used without question for high-pressure steam lines. Both gas and arc welding are widely used, with the arc gaining somewhat in favor.

The field use of X-ray testing and induction stress-relieving of welds is not common practice among the industrials.

Men and Machines

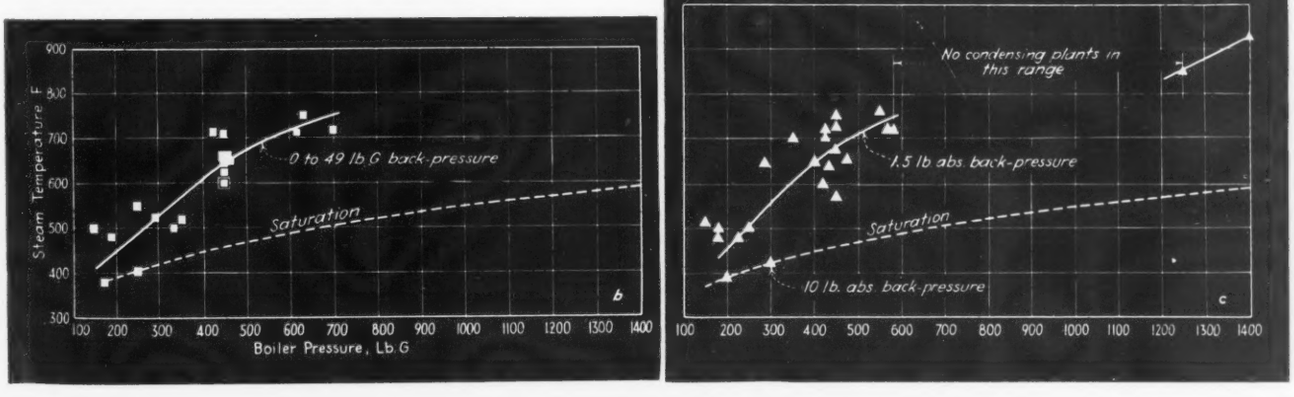
Finally we come to the dependability of men and machines. Are the designers of plants in a rut? A few think so, but more insist that the up-to-date designer will not overlook any bets, whether or not they are conventional. Of course, there is a limit to his gambling with the owner's money. Other things being equal, tested devices and hookups are better. Yet there is more pioneering today than at any time in the past 20 years.

Many of the thoughts stated arose directly from comments made to the editor by the following engineers:

J. Howard Cather — *Eastman Kodak Company;* Russell S. Clark —*Pittsburgh Plate Glass Company;* Edward R. Feicht—*Container Corporation;* Fred Gibson — *American Sugar Refining Company;* Dan Gutleben—*Pennsylvania Sugar Company;* Warren Lewis—*New Yorker Hotel;* Geo. A. Orrok—*Consulting Engineer;* Harry M. Spring—*Mutual Boiler Insurance Co. of Boston;* W. W. Starke and Mr. Lowes—*Forstman Woolen Company;* Alfred Vaksdal—*Corning Glass Works.*

The opinions here expressed are, of course, a composite, and it should not be assumed that any of the foregoing engineers agree with all of them.

WITH VARIOUS TURBINE—EXHAUST PRESSURES



WEIRTON

Weirton faced mounting loads, with two L.P. plants, 10 and 25 years old. Steam from new 800-lb. top handles 100% makeup, replaces oldest boilers, exhausts to existing turbines, adds 10,000 kw. (20,000 kw. ultimate) to capacity. Total savings: 15,000 tons of coal per month

WEIRTON Steel Co., Weirton, W. Va., has superposed two 400,000-lb. per hr. boilers (825 lb., 820 F) and one 10,000-kw. turbine on two old plants (215 and 160 lb.). Savings from all sources, after one year's operation, aggregate 15,000 tons of coal per month.

The Situation

Growing power demands began to crowd capacity in 1934. All load was generated locally; power was supplied by two low-pressure plants. Available feedwater supply was 100% treated makeup (barometric condensers).

Larger plant (*A*) generated steam at 215 lb. and 495 F for five 7,500-kw. turbines. After 10 to 15 years' service, efficiencies were still good. Its 35 boilers were coal-fired, some by pulverizers, some by underfeed stokers. Much of the steam was generated with steel-mill waste fuel and waste heat. Load used plant capacity to the limit.

Smaller power plant (*B*) contained two 3,200-kw., 150-lb. turbines and three 1,000-kw. mixed and low-pressure turbines. *A* and *B* were connected electrically, but not by steam lines. Prime movers in *B* were worth preserving, but the boiler plant was 25 years old and obsolete.

Present Program

Weirton decided to continue generating all power and to add enough steam capacity at plant *A* to permit dismantling boilers of plant *B*. New steam capacity at *A* could be provided at 225 lb., or by a high-pressure "top." Top would require much less additional steam capacity. 800 lb. and 1,200 lb. pressure were compared. The two cost the same, but 800 lb. required about 25% more steam. 800 lb. was chosen because its greater steam output was needed to replace the 160-lb. boilers and because 800 lb. seemed safer than 1,200 lb. for 100% treated makeup.

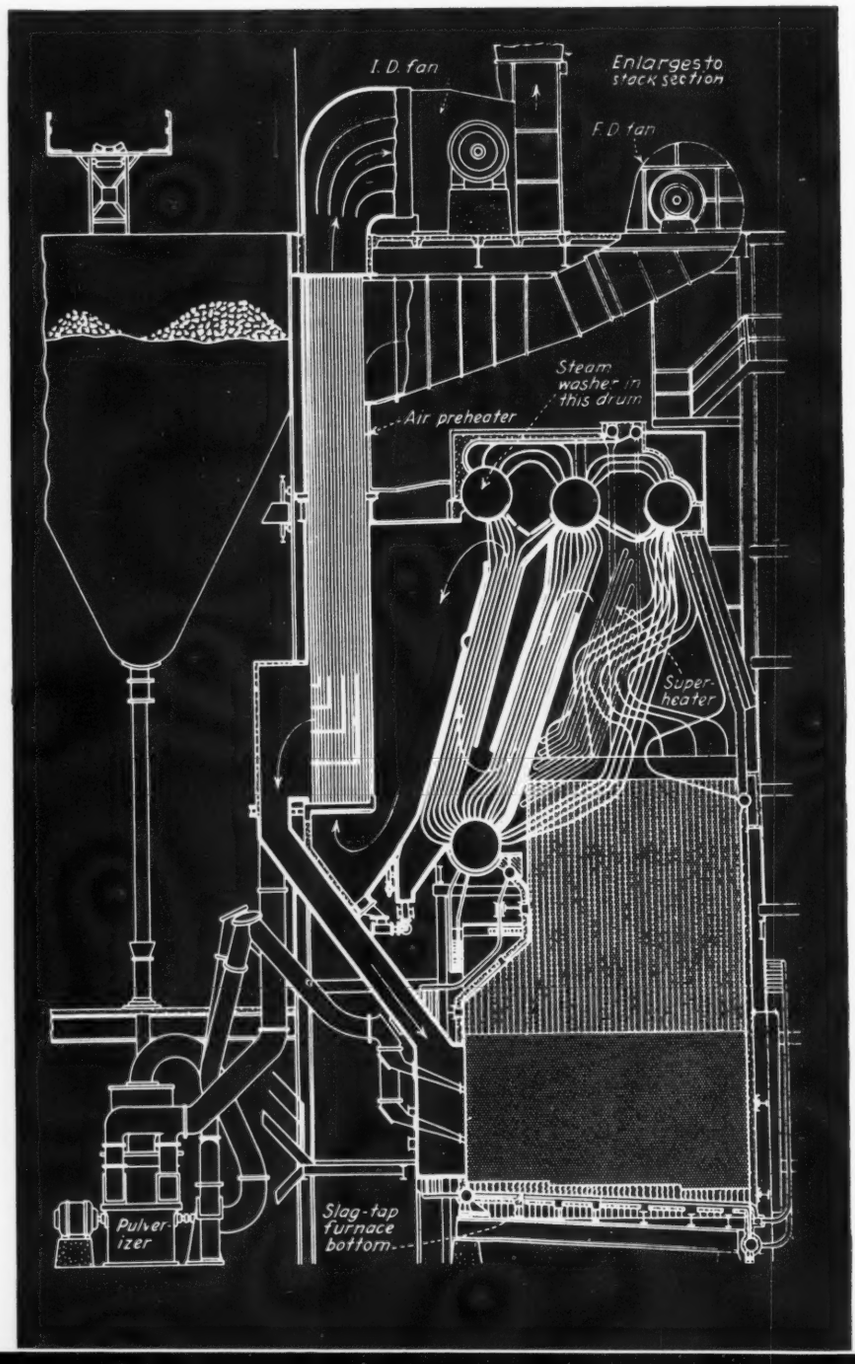
A superposed plant showed many advantages, compared with extension of 225-lb. systems. First, a single 10,000-kw. turbine top would reduce overall plant steam rate 30% and a second turbine (to be installed later) would cut it still more. Increasing capacity with a top required no added condensing equipment or condensing-water supply. The top could be arranged to take most of the violent load swings, leaving low-pressure boilers free to operate at low load on waste heat and by-product fuel. Every kilowatt generated by the top would produce enough exhaust steam to generate two more kw. in the low-pressure condensing turbines. Thus, a 3,000-kw. load increase on the topping turbine would add 9,000 kw. to plant capacity.

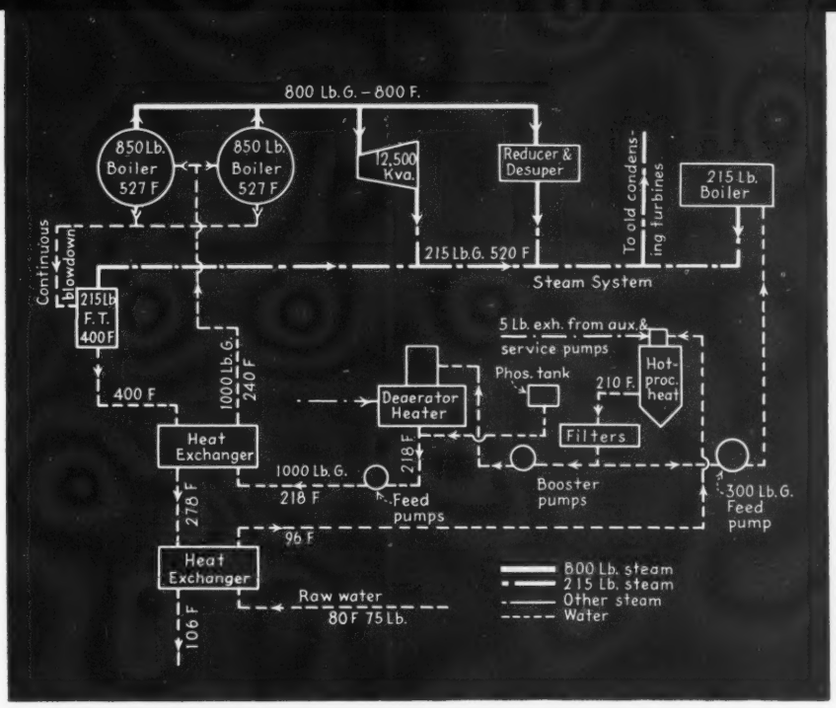
Boiler selection was based on the following requirements: 100% makeup, violent load fluctuations, reliability. Stirling-type boilers were selected largely because of the feedwater. The design chosen gives liberal steam-drum volume, moderate heat-release rates (25,000 B.t.u. normal) and moderate evaporation rates. Washer in boiler drum makes clean steam doubly sure.

Each of the two B.&W. boilers generates 825-lb., 820-F steam at 315,000-lb. per hr. normal load and peak of 400,000 lb. Either can operate the "10,000-kw." turbine-generator at 12,500 kw. if power factor permits. Second turbine was held for later installation, but two boilers were required at the start for absolute dependability.

Rated 12,500 kva. (10,000 kw. at 0.80 p.f.), steam end of G.E. turbine is sized to deliver full 12,500 kw., when 100% p.f. permits. Throttle steam conditions are 800 lb., 800 F. To handle rapid and large load swings, pulverized coal with slag-tap furnace was specified. Boilers also equipped with coke-oven gas burners to use excess gas on week-ends and holidays. Each boiler has two pulverizers, one

Steam-generating units: two 400,000-lb. per hr. max. capacity at 825 lb. and 820 F





Flow diagram. Feature: Feedwater supply is 100% treated makeup (barometric condensers)

steam-driven, one motor-driven. Forced- and induced-draft fans are steam driven. Steam-driven auxiliaries make high-pressure plant independent of power interruptions.

Feedwater

Feedwater is chemically treated in two steps: First, hot-process lime-soda; second, meta-phosphate. Leaving hot-process tanks, water is filtered and heated to 218 F in 600,000-lb. per hr. deaerating heater. From storage it gravitates to boiler-feed pumps, then passes through blowdown heat exchangers to steam washers in boiler drums. The secondary phosphate treatment is applied at the feed-pump suction. Continuous 10% blowdown keeps solid concentration in boiler water under 2,000 p.p.m. Blowdown system includes flash tank, high-pressure heat exchanger, raw-water heat exchanger.

Combustion control requirements were efficiency, simplicity, accessibility, reliability, flexibility. Average total load on both boilers is 600,000 lb. per hr., with quick swings of 150,000 lb.

Load Change

Load change varies steam header pressure from normal and thereby causes master sender to deliver an impulse to two compensating boiler relays, which divide total load between the boilers as desired. Impulse from each boiler relay passes to three ratio-type relays, two for fuel control of individual mills and one for air-flow control. Impulses from coal-feed relays control rate of coal feed to mills and rate of primary air flow. "Mill-charge corrector" automatically adjust fuel feed to maintain a predetermined quantity of coal in the mill for each load.

Coke-oven gas may be supplied to the main burner, but a fixed minimum pressure must be maintained in the gas main. To insure use of available excess gas, a diaphragm regulator, connected to the main, is adjusted for minimum pressure. Excess gas "spills over" to the burner. Heat input represented by gas fuel is allowed for by the coal control system. Furnace draft also is automatically regulated.

A year's operating experience with this plant has fully justified the 800-lb. "top." Most notable result is the saving of 15,000 tons of coal per month.

PRINCIPAL EQUIPMENT IN WEIRTON STEEL CO. PLANT
Weirton, West Virginia

Boilers and water-walls	Babcock & Wilcox Co.
Boiler, heating surface 20,487 sq.ft.; water-walls 4,277 sq.ft.; max. continuous steaming cap., 400,000 lb. per hr.; working press., 850 lb. G.; total steam temp., 820 F; Furnace volume, 17,280 cu.ft.; B.t.u. liberated per hr., 31,000 maximum per cu.ft.	
Superheater	Babcock & Wilcox Co.
Steam washer, cap	Babcock & Wilcox Co.
Air heater, 49,500 sq. ft	Babcock & Wilcox Co.
Boiler and furnace settings	Babcock & Wilcox Co.
Boiler heat insulation	Johns-Manville Co.
Furnace refractories	M. H. Detrick Co.
Armor blocks on water walls	Babcock & Wilcox Co.
Boiler ducts and breechings	Babcock & Wilcox Co.
Stack	Babcock & Wilcox Co.
Structural-steel	Babcock & Wilcox Co.
COMBUSTION EQUIPMENT:	
Automatic combustion control	Hagan Corp.
Soot blowers	Diamond Power Specialty Corp.
Pulverized coal burners	Babcock & Wilcox Co.
Gas burners	Babcock & Wilcox Co.
Coal pulverizers	Combustion Engineering Co.
Pulverizer turbine and gears	DeLaval Steam Turbine Co.
Coal feeders	Combustion Engineering Co.
Coal-feeder drive	Combustion Engineering Co.
Forced-draft fans	Buffalo Forge Co.
Forced-draft-fan drive, geared steam turbine	Terry Steam Turbine Co.
Forced-draft driving turbine gears	Terry Steam Turbine Co.
Induced-draft fans	B. F. Sturtevant Co.
Induced-draft-fan drive, geared steam turbine	Terry Steam Turbine Co.
Induced-draft fan driving turbine gears	Terry Steam Turbine Co.
COAL HANDLING EQUIPMENT:	
Coal handling	Gifford Wood Co.
Coal bunker	Weirton Steel Co.
ASH HANDLING EQUIPMENT:	
Ash-handling equipment on furnace, type, sluicing	Hydro-Ash Corp.
Ash-handling equipment on flyash system	Hydro-Ash Corp.
VALVES:	
Safety valves	Consolidated Ashcroft Hancock Co.
Blowdown valves	The Babcock & Wilcox Co.
Non-return valves	Edward Valve & Mfg. Co.
Feed-line stop and check valves	Edward Valve & Mfg. Co.
Globe, gate and check valves	Chapman Valve Mfg. Co.
Reducing valve	Mercon Regulator Co.
Continuous blowdown-control valves	Consolidated Ashcroft Hancock Co.
Forged steel valves	Edward Valve & Mfg. Co.
Power-control valves	Consolidated Ashcroft Hancock Co.
PIPING, TRAPS AND STRAINERS:	
Piping contractor	Grinnell Co.
Pipe heat insulation	Johns-Manville Co.
Expansion joints	Grinnell Co.
Low-pressure traps	Crane Co.
Strainers	H. A. Brassert & Co.
FEEDWATER SYSTEM:	
Water columns	Diamond Power Specialty Corp.
Floor-level water columns	Diamond Power Specialty Corp.
Feedwater regulators	Swartwout Co.
Boiler-feed pumps	Ingersoll-Rand
Boiler-feed-pump turbine drives	Moore Steam Turbine Corp.
Feed-pump governors	Swartwout Co.
Chemical feeding equipment	Cochrane Corp.
Hall system of phosphate feeding	Hagan Corp.
Feedwater deaerating heater	Elliott Co.
Continuous blowdown equipment	Foster Wheeler Corp.
METERS:	
Boiler meters	Bailey Meter Co.
Steam flowmeters	Bailey Meter Co.
Gas and air flowmeters	Bailey Meter Co.
Steam, flow, pressure and temp. recorders	Bailey Meter Co.
Feedwater flowmeters	Bailey Meter Co.
Boiler water-level recorders	Bailey Meter Co.
Boiler-loader indicators	Hagan Corp.
Steam-pressure gages, indicating	Consolidated Ashcroft Hancock Co.
Water-pressure gages, indicating	Consolidated Ashcroft Hancock Co.
Gas-pressure gages, indicating	Bailey Meter Co.
Turbine-pressure gages, indicating	Consolidated Ashcroft Hancock Co.
Turbine-pressure gages, recording	Bailey Meter Co.
Turbine-speed indicators	James G. Biddle Co.
Thermometers, industrial	Taylor Instrument Cos.
Thermometers, dial	Taylor Instrument Cos.
Thermometers, recording	Bailey Meter Co.
Pyrometers	Leeds & Northrup Co.
Draft gags	Bailey Meter Co.
Draft gages, multiple-point	Bailey Meter Co.
CO_2 recorder	Leeds & Northrup Co.
GENERATING UNITS:	
One 10,000-kw., 3,600-r.p.m.; throttle steam conditions 800 lb.g. 800 F; exhaust pressure 215 lb. G	General Electric Co.
Turbine connects directly to 12,500-k.v.a.; 0.80-p.f.; 3-phase, 60-cycle generator	General Electric Co.
Desuperheater on turbine exhaust	Elliott Co.
Automatic desuperheater control	Bailey Meter Co.
Generator air cooler	General Electric Co.
Oil cooler	Schutte & Koerting Co.
Service and auxiliary pumps	Dayton Dowd Co.
Station switchboard	General Electric Co.
Automatic voltage regulator	General Electric Co.
House switchboard	General Electric Co.
Station transformers	General Electric Co. and Wagner Electric Corp.
Station lighting transformers	Westinghouse Elec. & Mfg. Co.
Oil circuit breakers	General Elec. Co. and Westinghouse Elec. & Mfg. Co.

SCOTT PAPER

A high - pressure installation doubles steam capacity and increases electrical capacity 140% within existing building

SERVING a high-load-factor, 24-hr. demand for steam and electricity is the job of the power plant of the Scott Paper Co., Chester, Pa. By 1935, this job had become difficult, as Scott Paper reversed the common depression trend and installed new paper-making equipment and lengthened working hours to meet a rapidly rising volume of business.

Needed were vastly increased quantities of steam for process, more generator capacity to reduce necessary purchases of power and to provide slack for overloads and emergencies.

Limitations were mainly space, since impracticality of extending building made it necessary to squeeze new equipment into existing structure. The existing plant contained one 275-lb. turbine exhausting at 17 lb. to process and to a 200-lb.—17-lb. mixed-pressure condensing turbine. Total turbine capacity was 3,500 kw.—about two-thirds of power requirements were purchased. Steam for power and process was generated in one 300-lb. boiler of 20,400 lb. per hour capacity and four 200-lb. boilers with an aggregate capacity of 47,600 lb. per hour.

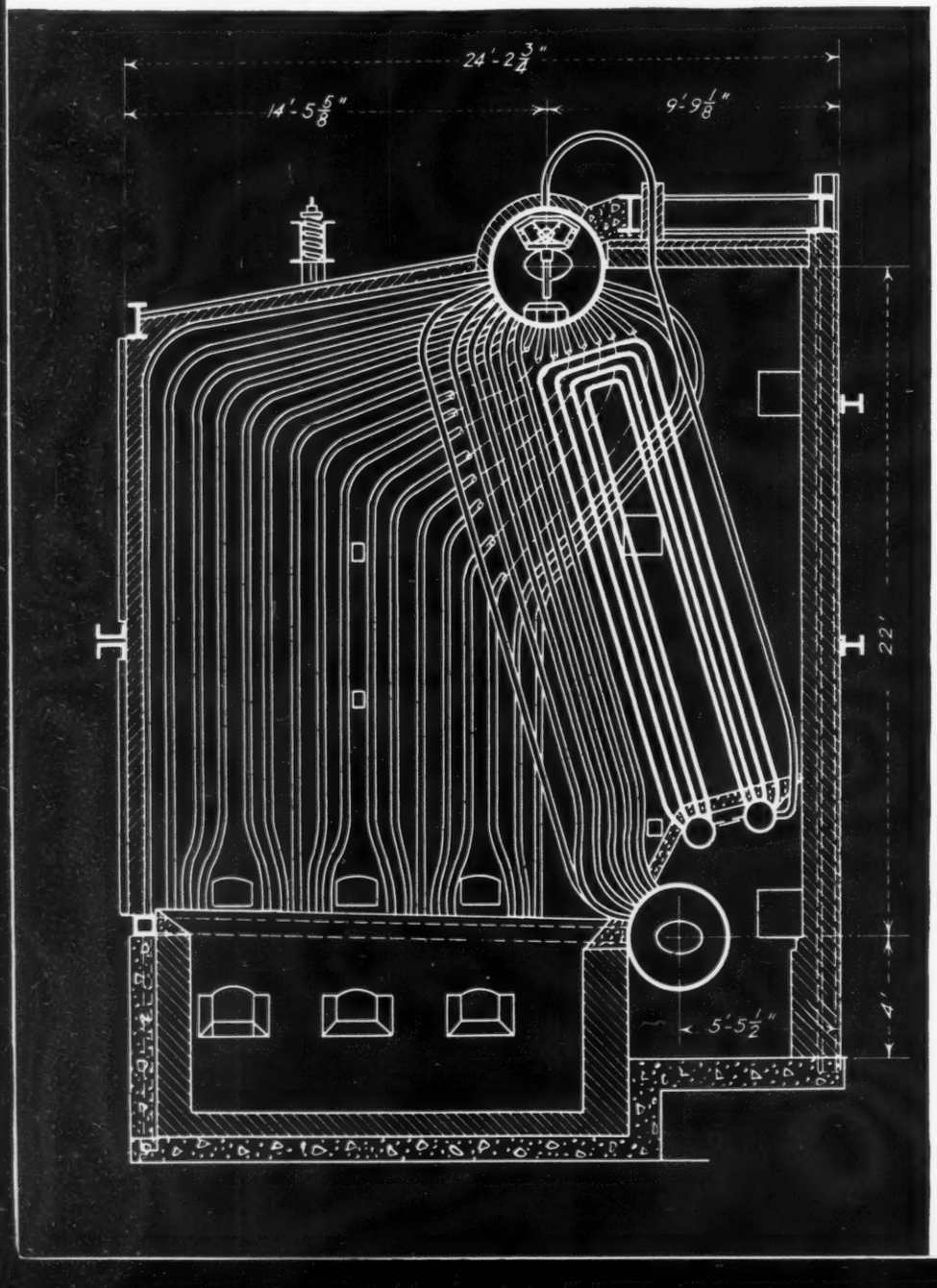
The Solution

A high-pressure boiler replaced two of the old small boilers; a high-pressure extraction turbine was fitted between the two existing turbines.

Reasons for the addition were: A single pound of high-pressure steam yields the needed power and still remains a pound of steam for process use. High pressure means compactness of equipment, an important factor where space is at a premium. High pressure means high efficiency; means cheaper power and steam.

As a result, steam capacity was doubled, power capacity increased 140%, power costs were reduced, and no building extension was required except a penthouse over the new boiler for fans and motor drives.

Steam-generating unit: 125,000 lb., per hr. max. capacity at 600 lb., 750 F



Balancing Power and Process

Steam supply from new boiler had to be available at all times, even when new turbine was shut down; process steam had to meet all mill demands; and as much local power was to be generated as consistent with meeting process requirements.

Automatically controlled reducing valves, one tieing the 600-lb. and 275-lb. sections and the other tieing the 275-lb. and 200-lb. sections, make it possible to supply the existing turbines and process from the new boiler.

Pressure-regulated throttle valves, in a unique arrangement, balance steam and power generation. Principal sources of 17-lb. process steam are the new turbine and the 1,500-kw., No. 2 machine, each equipped with a back-pressure-controlled governor. The backpressure feature of the governor on the new turbine is for emergency use only, however, the normal setting being 20 lb. Under these conditions, this machine operates at close to full load. Fluctuations in the demand for process steam are handled by the governor on the No. 2 turbine; the output of this unit thus depends on process-steam demand. If this demand drops below the range of the governor, pressure builds up in the process header until the governor of the new machine, set at slightly above normal exhaust pressure, takes hold. Throttling down new machine restores system balance.

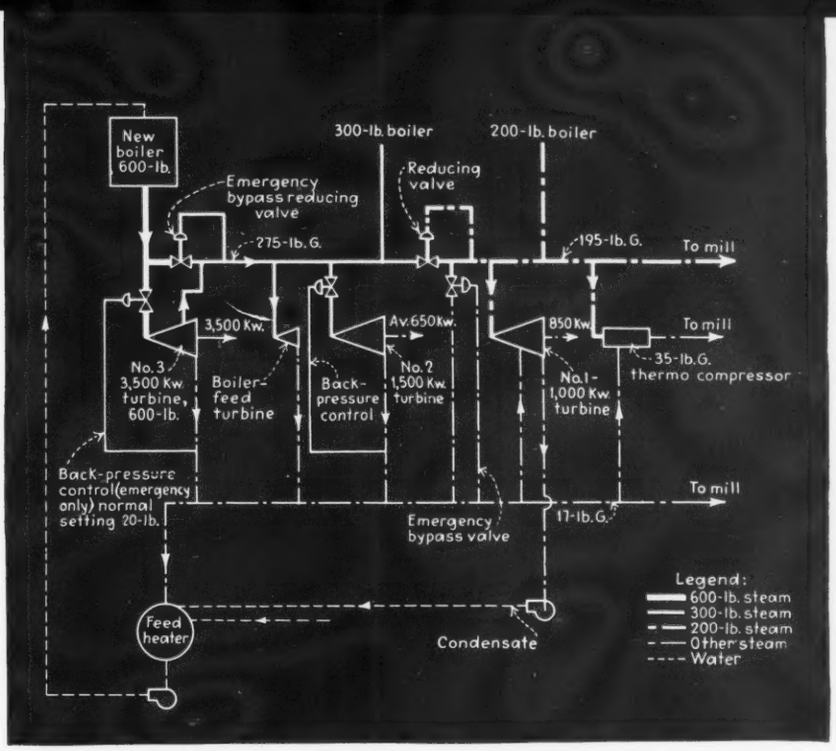
Further balancing of steam and power requirements is effected by the 1,000-kw. mixed-pressure unit, No. 1. This machine is supplied with either 200-lb. steam or 17-lb. steam, or both, as conditions dictate.

Feedwater Treatment

Makeup is river water with a hardness of 5 grains per gal. Not shown on the simplified flow diagram is the provision for softening and treating makeup and feed. Hardness is reduced to less than one grain per gal. in two zeolite softeners.

Steam-Generating Unit

The 2-drum, bent-tube B. & W. boiler with integral furnace, has a steaming capacity of 125,000 lb. per hour of 600-lb., 750-F steam. A water-cooled



Flow diagram. Feature: Back-pressure control arrangement balances power and process

floor in addition to water-cooled side and rear walls brings total heating surface up to 13,287 sq. ft. A 3-pass, 4-loop, U-tube convection superheater raises steam temperature to 750 F, and flue-gas heat is recovered in a 8,700-sq. ft. air preheater.

Firing of the oil fuel takes place in three combination steam-mechanical-atomizing burners designed for conversion to pulverized-coal firing. Bunker "C" oil is stored in three existing 100,000-gal. storage tanks and two 10,000-gal. service tanks. Steam preheats the fuel to 210 F. Furnace volume is 4,200 cu. ft., and maximum heat liberation is 26,300 B.t.u. per cu. ft. per hr.

Combustion is automatically regulated by steam pressure in the 600-lb. steam header. The control system embraces air supply, fuel supply, and induced draft, and is adjusted to supply 16% excess air.

The new boiler unit has a full complement of meters: a steam-flow air-flow meter, a 5-point draft gage, a 600-lb. pressure recorder, and a 4-pen recorder for superheated-steam temperature, preheater exit-air temperature, preheater entrance-flue-gas temperature, and preheater exit-flue-gas temperature.

Turbine Unit

The G.E. turbine, of 3,500-kw. capacity, operates at 3,600 r.p.m. and is arranged for extraction of steam at 275 lb. It is directly connected to a 4,375-kva, 60-cycle, 3-phase, 600-volt generator.

Auxiliaries

Turbine-driven boiler-feed pumps increase the supply of 17-lb. process steam. Steam at 275 lb., extracted from the new turbine, drives the feed-pump turbines, which exhaust to the process header.

Variable-speed, slip-ring motors drive both forced- and induced-draft fans. Each system is supplied by a single unit, the forced-draft fan having a capacity of 40,000 c.f.m. and the induced-draft fan a capacity of 100,000 c.f.m.

Electrical System

The three generators operate in parallel with an outside service. Something over 15% of present power requirements are met by purchased power. Distribution within the plant is from a main switchboard with individual feeder switches.

PRINCIPAL POWER PLANT EQUIPMENT

Scott Paper Co., Chester, Pa.

Consulting Engineers.....Stone & Webster Eng. Corp.
Boilers and water walls.....Babcock & Wilcox Co.
Boiler, 1; heating surface total, 13,287 sq.ft.; max. continuous steaming cap. 125,000 lb. per hr.; working press. 630 lb. G.; total steam temp. 750 F; furnace volume 4,200 cu.ft.; max. B.t.u. liberated per cu.ft. per hr. 26,300
Superheater, 2,000 sq.ft.....Babcock & Wilcox Co.
Air heater, 8,700 sq.ft.....Air Preheater Corp.
Furnace refractories.....A. P. Green Fire Brick Co.
Boiler insulation.....Johns-Manville

COMBUSTION EQUIPMENT:
Automatic combustion control.....Bailey Meter Co.
Combustion control air pumps.....Ingersoll-Rand Co.
Soot blowers.....Diamond Power Specialty Corp.
Oil burners, 3 per boiler.....Babcock & Wilcox Co.
Oil pumps.....Schutte & Koerting Co.
Oil preheaters.....Griscom-Russell Co.
Oil-pressure control.....Bailey Meter Co.
Forced-draft fans, 1; cap. 40,000 c.f.m. .....American Blower Corp.
Forced-draft-fan drive, 150-hp., variable-speed slip-ring motor
General Electric Co.
Induced-draft fan, 1; cap. 100,000 c.f.m. .....American Blower Corp.
Induced-draft-fan drive, 200-hp., variable-speed slip-ring motor
General Electric Co.

VALVES:
Safety valves.....Consolidated Ashcroft Hancock Co.
Blowdown valves.....Yarnall-Waring Co.
Non-return valves.....Edward Valve & Mfg. Co.
Stop and check valves in feed lines.....Edward Valve & Mfg. Co.
High-pressure valves.....Edward Valve & Mfg. Co.
Reducing valves.....Swartwout Co.

PIPING, TRAPS AND STRAINERS:
Piping contractor.....Benjamin F. Shaw Co.
Pipe insulation.....Johns-Manville
High-pressure traps.....W. H. Nicholson & Co.

FEEDWATER SYSTEM:
Water columns.....Diamond Power Specialty Co.
Feedwater regulators.....Northern Equipment Co.
Boiler-feed pumps, 2; cap. each, 350 g.p.m.; 4,050 ft. head
Ingersoll-Rand Co.
Drive, 224-hp., 3,550 r.p.m. turbines.....Terry Steam Turbine Co.
Feed-pump governors.....Fisher Governor Co.
Feedwater-purification equipment.....Permutit Co.
Feedwater-degenerating heater.....Cochrane Corp.
Feedwater treatment.....Hall Laboratories

METERS:
Boiler meter and control board.....Bailey Meter Co.
Turbine meter and control board.....General Electric Co.
Steam flowmeter.....Bailey Meter Co.
Temperature recorders.....Foxboro Co.
Feedwater flowmeters.....Cochrane Corp.
Liquid-level recorders.....DeGiers Co.
Boiler water-level recorders.....Foxboro Co.
Steam-pressure gages, indicating...Consolidated Ashcroft Hancock Co.
Water-pressure gages, indicating...Consolidated Ashcroft Hancock Co.
Oil-pressure gages, indicating.....Consolidated Ashcroft Hancock Co.
Turbine-pressure gages, indicating.Consolidated Ashcroft Hancock Co.
Turbine-pressure gages, recording.....Brown Instrument Co.
Turbine-speed indicator.....James G. Biddle Co.
Thermometers, industrial .....Consolidated Ashcroft Hancock Co.
Thermometers, dial .....Consolidated Ashcroft Hancock Co.
Thermometers, recording.....Bailey Meter Co.
Temperature recorders.....Brown Instrument Co.
Temperature recorders, multiple-point.....Foxboro Co.
Generator temperature recorder.....General Electric Co.
Draft gages.....Bailey Meter Co.

GENERATING UNITS:
One, 3500-kw., 3600 r.p.m. turbine; throttle conditions 600 lb. G, 750 F; automatic extraction at 275 lb.; exhaust 18 lb. G.
General Electric Co.
Automatic control of high-pressure bleed.....General Electric Co.
Turbine connects directly to 4,375 k.v.a., 0.80 p.f.; 3-phase, 60-cycle, 600-volt generator.....General Electric Co.
Automatic desuperheater control.....Swartwout Co.
Automatic control on high-pressure bleed.....General Electric Co.
Generator air cooler.....General Electric Co.
Oil cooler.....Schutte & Koerting Co.
Oil purifier.....DeLaval Steam Turbine Co.
Exciters, motor generators.....General Electric Co.
Station switchboard.....General Electric Co.
Station transformers.....General Electric Co.
Station lighting transformers.....General Electric Co.
Oil circuit breakers.....General Electric Co.
Air-break circuit breakers
I-T-E Circuit Breaker Co. & General Electric Co.

TIMKEN

400-lb., 630-F boiler and condensing turbine produce three times former power with same amount of fuel

INCREASE in power load due to expansion of the Columbus plant of the Timken Roller Bearing Company required increased generating capacity. A block of power is generated, the rest is purchased. Remodeling the existing 150-lb., 100-F superheat plant by addition of a 400-lb., 630-F condensing unit will result in generation of 2,250 kw. with the fuel formerly used to produce 750 kw. All engineering work was done within the Timken organization.

Before remodeling, plant consisted of three 3,000-sq. ft. boilers, stoker fired, delivering steam at 150 lb. G and 100 F superheat to a 750-kw. turbine. Ordinarily about 15,000 lb. of steam per hr. is bled from the turbine at 5 lb. G, steam demand running as high as 30,000 lb. per hr. during the winter. Operation is constant at full load for six days a week, bled steam being used for process and heating.

New equipment will operate about October, 1937; construction was started in June. One original 3,000-sq.ft. boiler was removed, leaving space for the new steam generator in the existing boiler room. New turbine, twice the size of the original, is in the old coal-storage room; the only new building construction required is making this space into a turbine room and adding a new coal silo. Roof of new turbine room, 20x60 ft., is reinforced concrete and forms the base of a 3-cell cooling tower, being sheathed with copper to form a water-tight basin. Remodeling is progressing without affecting plant operation; no shutdown of the existing turbine is necessary. Provision is made to permit future expansion, likewise without interfering with power generation.

Steam-Generating Unit

One 3-drum, bent-tube steam-generating unit, 60,000 lb. per hr. capacity at 400 lb., 630 F, built by Foster Wheeler Corp., is being installed. This unit is fired by a 7-retort, Westinghouse stoker, with a projected grate area of 152 sq. ft. The new steam-generating unit has a designed operating efficiency of 86%. Special attention has been given to the combustion-control system to permit high-efficiency operation when burning any of a wide range of coals purchased on the basis of least fuel cost per 1,000 lb. of steam produced. Instruments, compactly mounted on control panel, show coal feed, steam flow, CO_2, water level and draft pressures, and permit operators to adjust stoker settings quickly and accurately to suit a change of fuel. Steam, flue-gas and feedwater temperatures are recorded. Needle-valve micrometer control assures maintaining CO_2 within a 1% variation at all times regardless of load.

All tubing for boiler unit is Timken Sicromo, a silicon-chrome-molybdenum alloy-steel seamless tubing. This alloy was chosen for its high strength at elevated temperatures and superior resistance to oxidation under conditions encountered in boiler and superheater. Economizer is also fitted with Timken seamless tubing.

Forced- and induced-draft fans are constant-speed, squirrel-cage, motor-driven units with damper control regulated automatically. All fans, pumps, drive motors and turbines are roller-bearing equipped.

Piping and Valves

High-pressure steam lines are Timken seamless tubing with welded-joint construction. Six Foster Wheeler bellows-type, stainless-steel expansion joints are part of the piping system; these eliminate usual expansion loops and effect a considerable saving in weight.

Valves are roller-bearing equipped; thrust occasioned by wrenching closed is taken by tapered bearing and adjusting nut incorporated in yoke assembly. No matter how tightly closed, gate valves can be opened easily by hand.

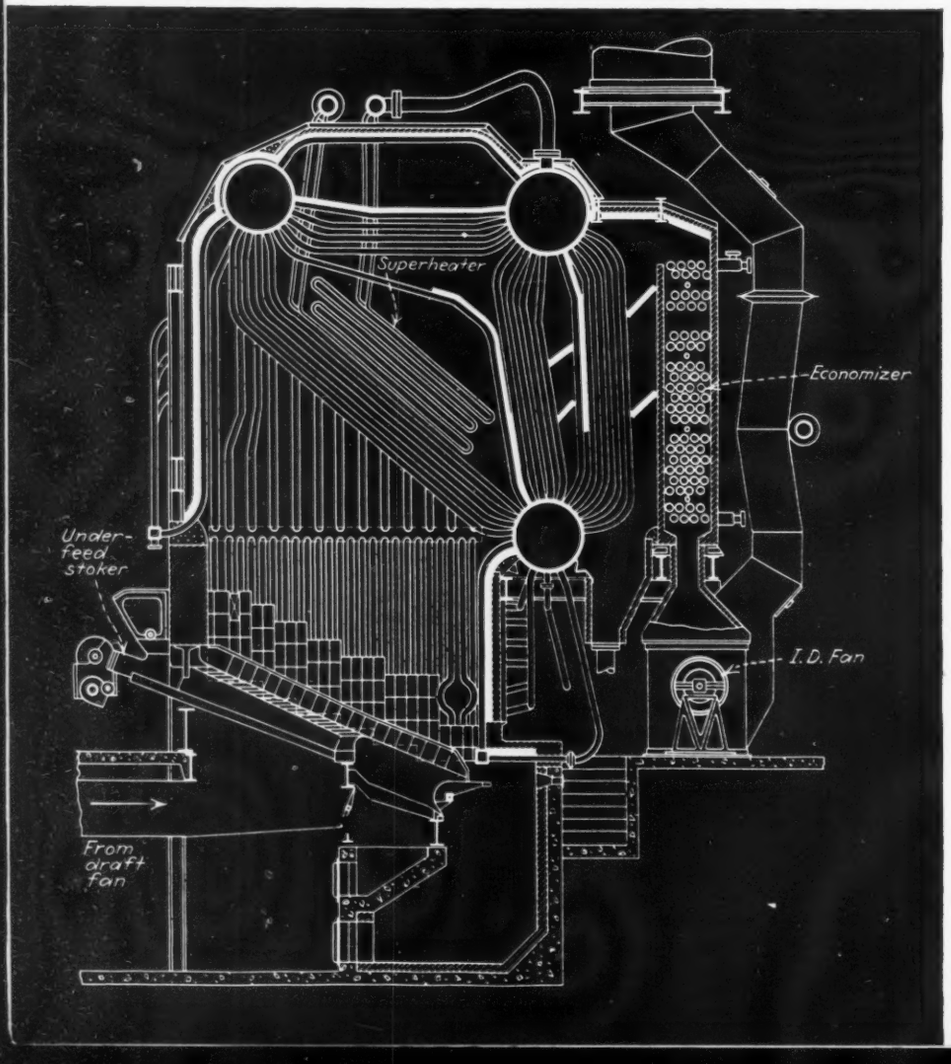
Coal and Ash Handling

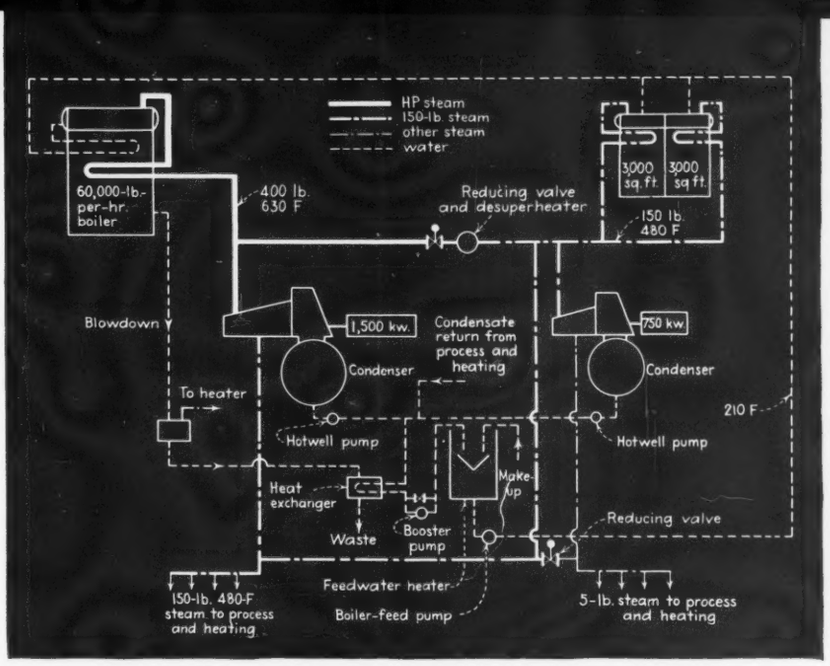
Coal is dumped from cars through a track hopper, an apron feeder taking it to a bucket elevator which fills the storage silo. The upper live-storage portion of this silo holds approximately a 36-hr. supply of coal while the lower, dead-storage, section contains a 5-day supply. Operation of the coal-handling system is under automatic control. Coal feeds from the live storage directly to a new Jeffrey-Taylor weigh feeder, and discharges through a spiral conveyor to the stoker hoppers. All coal entering the boiler house is thereby weighed; no bunker is required within the boiler house.

Dry ash from the pits is dumped into a hopper connected to an 8-in. ash-intake pipe where a steam-ejection system carries it 180 ft. to a 10-ft. diameter glazed-tile storage tank 20 ft. high. This system has a capacity of 10 tons of ash per hr. and steam consumption will not exceed 300 lb. per ton of ash handled.

The 1,500-kw. turbine, which, like the 750-kw. unit, may be operated

Steam-generating unit: 600,000-lb.-per-hr. max. continuous capacity at 400 lb. and 630 F





Flow diagram. Feature: New turbine bleed point supplies older turbine and processes

either bleed or full condensing, will utilize about 44,000 lb. of steam per hr. at 500 lb., 630 F when full bleeding. This unit can be operated alone, or in parallel if desired. The new turbine is also bled into the present 150-lb. header which supplies steam to the old turbine or to the factory for process. The high-pressure header is also connected to a low-pressure header through a reducing valve and desuperheater.

3,500-sq. ft. condenser has Muntz metal tubes rolled in at both ends and welded-plate expansion joint in the shell. New 3-cell cooling tower will allow maintaining a condenser pressure of about 2 in. mercury abs.

Makeup, taken from warm side of cooling-tower supply, is softened by continuous hot process-water treating plant. Feedwater of required alkalinity has less than 8 p.p.m. hardness.

PRINCIPAL POWER-PLANT EQUIPMENT
Timken Roller Bearing Co., Canton, Ohio

Boilers and waterwalls.....Foster Wheeler Corp.
Boiler, 1; heating surface total, 4,800 sq.ft.; waterwalls, 654 sq.ft.; max. continuous steaming cap., 60,000 lb. per hr.; working press., 433 lb. G.; total steam temp., 630 F; furnace volume, 1,800 cu.ft.; max. B.t.u. liberated per cu.ft. per hr., 45,200
Superheater.....Foster Wheeler Corp.
Economizer, 3,120 sq.ft.....Foster Wheeler Corp.
Steam washer, cap. 60,000 lb. per hr.....Foster Wheeler Corp.
Boiler and furnace settings.....Foster Wheeler Corp.
Furnace refractories.....General Refractories Co.
Boiler insulation.....Johns Manville Co.
Armor blocks on waterwalls.....Foster Wheeler Corp.
Boiler ducts and breechings.....Foster Wheeler Corp.

COMBUSTION EQUIPMENT:
Automatic combustion control.....Republic Flow Meters Co.
Combustion-control oil pumps.....Republic Flow Meters Co.
Soot blowers.....Vulcan Soot Cleaner Co.
Stokers, 1, continuous ash-discharge type; 7 retorts; protected grate area, 152 sq.ft.....Westinghouse Elec. & Mfg. Co.
Stoker drive, 5-hp., 3600-r.p.m. steam turbine Westinghouse Elec. & Mfg. Co
Speed control.....Republic Flow Meters Co.
Forced-draft fans, 1; cap. 25,000 c.f.m.; static press. 5 in.; double-inlet.....Clarage Fan Co.
Forced-draft-fan drive, 25-hp., 1800-r.p.m. induction motor General Electric Co.
Forced-draft-fan damper control.....Republic Flow Meters Co.
Induced-draft fan, 1; cap. 30,000 c.f.m.; static press. 4.2 in. Clarage Fan Co.
Induced-draft-fan drive, 50-hp., 1200-r.p.m. induction motor General Electric Co.
Induced-draft-fan damper control.....Republic Flow Meters Co.

COAL-HANDLING EQUIPMENT:
Coal handling, apron feeder, bucket elevator, and tripper Jeffrey Mfg. Co.
Coal-handling equipment motors, 3.....Allis-Chalmers Mfg. Co.
Coal silo, concrete, 16 ft. int. diam., 48 ft. high....Jeffrey Mfg. Co.
Coal scales.....Jeffrey Mfg. Co.

ASH-HANDLING EQUIPMENT:
Ash-handling equipment on furnace, Steamatic..United Conveyor Corp.

VALVES:
Safety valves.....Consolidated Ashcroft Hancock Co.
Blowdown valves.....Cochrane Corp.
Forged-steel needle valves.....Consolidated Ashcroft Hancock Co.
Non-return valves.....Edward Valve & Mfg. Co.
Non-return valves on turbine-bleed lines....Edward Valve & Mfg. Co.
Stop and check valves in feed lines.....Walworth Co.
Oil-closing turbine bleeder valve.....Allis-Chalmers Mfg. Co.
High-pressure valves.....Walworth Co.
Medium-pressure valves.....Walworth Co.
Low-pressure valves.....Walworth Co.
Reducing valves.....Swartwout Co.
Atmospheric-relief valves.....Edward Valve & Mfg. Co.

PIPING, TRAPS & STRAINERS:
Piping contractor.....Huffman Wolfe Co.
Pipe heat insulation.....Johns Manville Co.
Expansion joints.....Foster Wheeler Corp.
Expansion joints.....Ross Willoughby
High-pressure traps.....Armstrong Machine Works
Low-pressure traps.....Armstrong Machine Works
Strainers.....Edward Valve & Mfg. Co.

FEEDWATER SYSTEM:
Water columns.....Diamond Power Specialty Co.
Floor-level water columns.....Diamond Power Specialty Co.
Feedwater regulators.....Northern Equipment Co.
Excess-pressure regulators.....Swartwout Co.
Boiler-feed pumps, 2; cap. each 120 g.p.m.; 1265-ft. head Ingersoll-Rand Co.
Feed-pump drive, 1; 100-hp., 1800-r.p.m. motor..Allis-Chalmers Mfg. Co.
Drive, 1; 100-hp., 1800-r.p.m. turbine.....Allis-Chalmers Mfg. Co.
Makeup-water pump, 1; cap. 120 g.p.m.....Allis-Chalmers Mfg. Co.
Makeup-water pump drive, motor.....Allis-Chalmers Mfg. Co.

FEEDWATER-PURIFICATION EQUIPMENT:
Feedwater-deaerating heater.....Cochrane Corp.
Deaerator control.....Cochrane Corp.
Feedwater heaters.....Cochrane Corp.
Continuous-blowdown equipment.....Cochrane Corp.
Heater condensate pumps, 2; 120 g.p.m. cap.; 70-ft. head Allis-Chalmers Mfg. Co.
Feedwater treatment.....Hot process
Feedwater-treatment injection pumps, 2.....Ingersoll-Rand Co.

METERS:
Boiler meter and control board.....Republic Flow Meters Co.
Turbine meter and control board.....Allis-Chalmers Mfg. Co.
Boiler meters.....Republic Flow Meters Co.
Steam flowmeters.....Republic Flow Meters Co.
Steam, flow, pressure and temp. recorders..Republic Flow Meters Co.
Feedwater flowmeters.....Republic Flow Meters Co.
Boiler water-level indicators.....Republic Flow Meters Co.
Liquid-level recorders.....Republic Flow Meters Co.
Boiler water-level recorders.....Republic Flow Meters Co.
Condensate tester.....Cochrane Corp.
Boiler-load indicators.....Republic Flow Meters Co.
Steam-pressure gages, indicating.....Republic Flow Meters Co.
Water-pressure gages, indicating.....Republic Flow Meters Co.
Gas-pressure gages, indicating.....Republic Flow Meters Co.
Oil-pressure gages, indicating.....Republic Flow Meters Co.
Turbine-pressure gages, indicating.....Republic Flow Meters Co.
Turbine-pressure gages, recording.....Republic Flow Meters Co.
Turbine-speed indicator.....Allis-Chalmers Mfg. Co.
Thermometers, industrial.....Taylor Instrument Cos.
Thermometers recording.....Republic Flow Meters Co.
Thermometers, recording.....Cochrane Corp.
Temperature recorders, multiple point.....Republic Flow Meters Co.
Temperature recorders, multiple point.....Cochrane Corp.
Pyrometers.....Republic Flow Meters Co.
Draft gages.....Republic Flow Meters Co.
Draft gages, multiple-point.....Republic Flow Meters Co.
CO_2 indicator and recorder.....Republic Flow Meters Co.

GENERATING UNITS:
One, 1,500-kw., 3,600-r.p.m. turbine; throttle conditions 400 lb. G.; 630 F; automatic extraction at 150 lb.....Allis-Chalmers Mfg. Co.
Automatic control of high-pressure bleed.....Allis-Chalmers Mfg. Co.
Turbine connects directly to 1,500-kva., 80-p.f., 3-phase, 60-cycle, 480-volt generator.....Allis-Chalmers Mfg. Co.
Desuperheater.....Swartwout Co.
Automatic desuperheater control.....Swartwout Co.
Automatic control on high-pressure bleed.....Allis-Chalmers Mfg. Co.
Generator air cooler.....Griscom Russell Co.
Oil cooler.....Andale Co.
Condensers, 3,500 sq.ft.....Allis-Chalmers Mfg. Co.
Cooling tower.....Lilie Hoffman Co.
Circulating pumps, 1 motor and 1 turbine, 3,300 g.p.m. Allis-Chalmers Mfg. Co.
Circulating-pump motor drive, induction, 75 hp., 1,800 r.p.m., 440 volt.....Allis-Chalmers Mfg. Co.
Condensate pump, 1 motor, 40 g.p.m.....Allis-Chalmers Mfg. Co.
1 turbine, 60 g.p.m.....Allis-Chalmers Mfg. Co.
Condensate-pump motor drive, induction, 5 hp., 1800 r.p.m., 440 volts.....Allis-Chalmers Mfg. Co.
Condensate-pump turbine drive.....Allis-Chalmers Mfg. Co.
Vacuum pump, evactor type.....Allis-Chalmers Mfg. Co.
House service pumps, 1.....Allis-Chalmers Mfg. Co.
Air compressors, 3.....Ingersoll-Rand Co.
Exciters, turbine driven, 1.....Allis-Chalmers Mfg. Co.
Exciters, motor driven, 1.....Allis-Chalmers Mfg. Co.
Station switchboard.....Allis-Chalmers Mfg. Co.
Automatic voltage regulator.....Allis-Chalmers Mfg. Co.
House switchboard.....Allis-Chalmers Mfg. Co.
Station transformers.....General Electric Co.
Station lighting transformers.....General Electric Co.

WILSHIRE

All exhaust from this 450-lb., 560-F plant is used in process, so steam drives throughout the plant are most economical

WHEN ALL exhaust from power equipment can be used in process, steam drives may prove most economical. This condition was found at the new oil refinery of Wilshire Oil Co., Santa Fe Springs, Calif. In this model plant, steam drives are used throughout except in the low-temperature acid plant, which is driven electrically by purchased power. The steam drives include many process pumps and others necessary in refinery operation, service-water pumps, and all power-plant auxiliaries.

At first thought, objection may be raised against steam piping running all over the refinery to the various power units. But steam must be transmitted for use in process. An exhaustive engineering study showed that it was more economical to transmit this steam at high pressure to where it was required by power units, and have these act as reducing valves to exhaust into the 15-lb. process lines.

Steam is provided by four bent-tube, 3-drum Foster Wheeler boilers, each having 3,610 sq. ft. of heating surface and a max. capacity of 45,000 lb. per hr. 450 lb. per sq. in., and 560 F were selected as meeting refinery requirements most economically. An extended surface economizer having 2,016 sq. ft. heating surface is under the rear bank of boiler tubes. Boiler baffling is so arranged that gas leaving the last pass of the boiler enters the economizer housing directly, although economizer is at ground level. This gives a very compact arrangement of equipment, the economizer being within the floor area occupied by the boiler. From bottom of economizer flue, gas goes through an under-floor duct to an induced-draft fan on the boiler-room floor.

Gas Passes

Arrangement of boiler and economizer provides short gas passes to the economizer, eliminating leaks and radiation losses; gives a convenient position of economizer for cleaning and servicing; reduces the amount of supporting steel required; places the induced-draft fan and its turbine drive close to the economizer gas outlet without having to mount it on steel work, and permits short flue connections to the base of the stack, thus getting full effect of stack height.

There are no forced-draft fans, and plant layout has been so arranged that all boiler auxiliary equipment is on the operating-floor level.

Firing is by three wide-range mechanical-atomizing oil and gas burners arranged on a horizontal line in the furnace front. The furnace is of a refractory air-cooled design, including the furnace floor. Air ducts on the furnace wall are formed by incasing them in expanded Transite having an air-cell construction.

In the refinery, cracking and rerun furnaces are fired with cracking-plant gas. This gas is stored in a special gas balance tank that automatically maintains the calorific value of the gas practically constant, which makes it easy to keep furnace conditions constant. Excess gas not required in the cracking and rerun furnaces is burned under the boilers as auxiliary fuel.

When producing 30,000 lb. of steam per hour and burning 18,000-B.t.u. oil, guaranteed boiler and furnace efficiency is 84%. Feedwater reaches the economizer at 220 F and enters the boiler at 317 F. Flue gas leaves the economizer at 390 F.

Chief loads for the boiler are turbine-driven pumps for circulating 16,000 g.p.m. of process water at pressures up to 100 lb. per sq. in., and other pumps necessary to process equipment. Process water is cooled in one of the largest cooling towers in the world, with a capacity of 10,000 g.p.m. from an inlet temperature of 125 F to 80 F, regardless of wind velocity. All boiler-feed pumps and induced-draft fans are also driven by high-pressure steam turbines. The high-pressure turbines exhaust into a 150-lb. main where steam temperature is approximately 420 F.

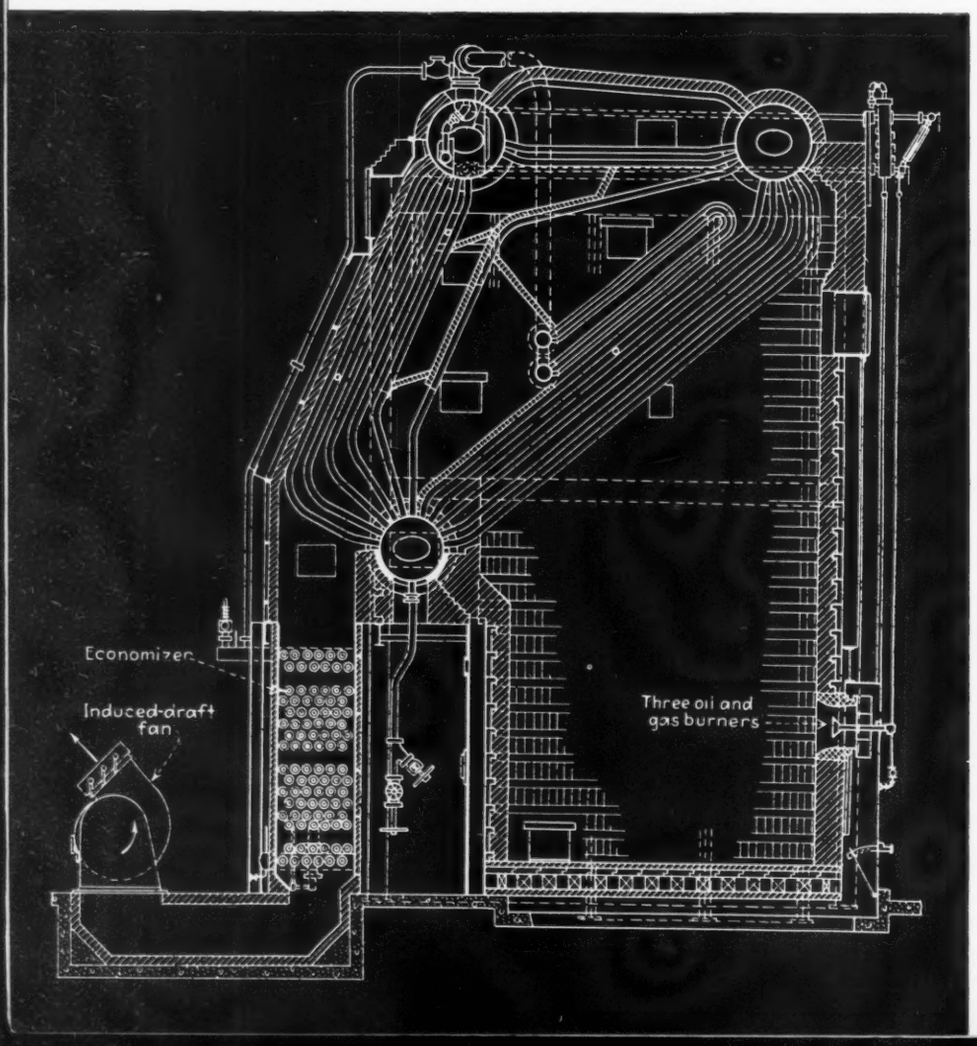
150-lb. Steam

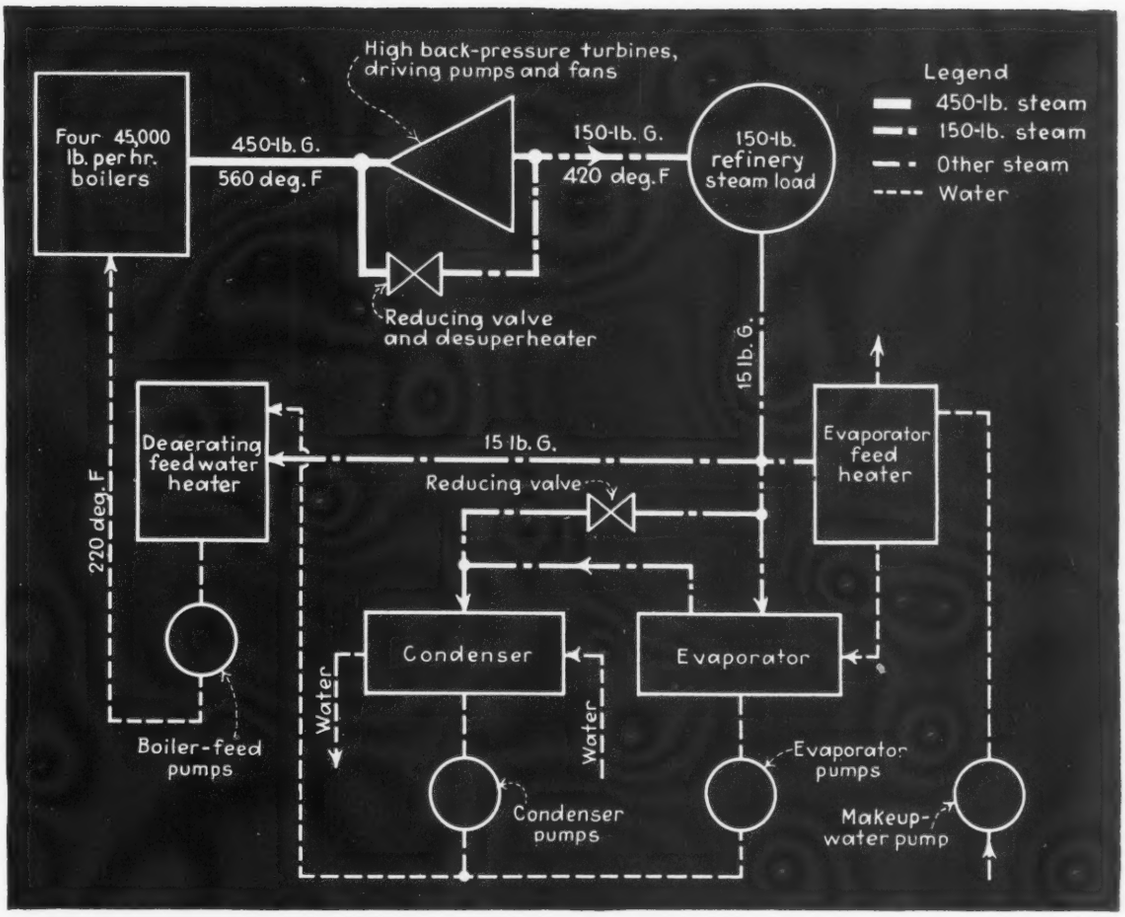
Steam is taken from the 150-lb. header to drive other pumps in the refinery. Among the more important of these are two hot-oil charging plunger-type pumps driven by 550-hp. engines. These pumps are among the largest of their type, operating at maximum speeds of 40 r.p.m., and developing pressures up to 1250 lb. per sq. in. A third engine-driven pump is of smaller capacity. All power units taking steam at 150 lb. exhaust at 15 lb.

The demands for 150-lb. steam are always in excess of the exhaust from the high-pressure turbines, a balance between the requirements of the two lines being maintained by a reducing valve and desuperheater.

A large percentage of feedwater is makeup obtained from evaporators. Any excess of 15-lb. steam above that required in the evaporator is discharged through a reducing valve into the evaporator condenser and is condensed for feedwater. Before evaporation, raw water is given a softening

Steam-Generating Unit: 45,000 lb. per hr. max. capacity at 450 lb. and 560 F.





Flow Diagram. Feature: Turbines driving pumps and fans exhaust into 150-lb. main to supply refinery power load.

treatment and is pumped into an open deaerating heater from which it flows to the evaporator, which is of the horizontal submerged, self-descaling type. Condensate from the condenser is pumped into a second deaerating heater before going to the feed pumps.

The four boilers are arranged two on each side of a firing aisle. Control of each pair of boilers and their meters is centered on a meter panel. Combustion air and fuel, and feedwater supply, are under automatic control. Meters are provided for measuring steam, water and fuel flow, and to indicate and record pressure, temperature, draft, steam flow-air flow relation, etc., so that the plant is operated under practical test conditions at all times, and therefore at its most economical efficiency.

PRINCIPAL EQUIPMENT IN POWER PLANT
Wilshire Oil Company, Santa Fe Springs, Cal.

Consulting Engineers.....R. M. Parsons Co.

Boilers, 4; heating surface each, 3,610 sq. ft.; max. continuous steaming cap., 45,000 lb. per hr.; working press., 450 lb. G.; total steam temp., 560 F; furnace volume, 6,400 cu. ft.; max. B.t.u. liberated per cu. ft. per hr., 10,000.....Foster Wheeler Co.
Superheater.....Foster Wheeler Co.
Economizer, 2,016 sq. ft.....Foster Wheeler Co.
Boiler and furnace settings.....Foster Wheeler Co.
Furnace refractories.....Bigelow-Liptak Corp.
Boiler heat insulation.....Philip Carey Co.
Boiler ducts and breechings.....Foster Wheeler Co.
Stack, contractor.....Western Pipe & Steel Co.

COMBUSTION EQUIPMENT:
Automatic combustion control.....Bailey Meter Co.
Soot blowers.....Diamond Power Specialty Corp.
Oil burners, 3 per boiler, mechanical-atomizing.....Peabody Engineering Corp.
Oil pumps.....Worthington Pump & Mach. Corp.
Oil heater.....Foster Wheeler Co.
Oil pressure control.....Bailey Meter Co.
Induced-draft fans, 1 per boiler, cap., 30,000 c.f.m. at 460 F; static press., 4.5 in.....Green Fuel Economizer Co.
Induced-draft fan drive, 32-hp. geared turbine.....Elliott Co.

VALVES:
Safety valves.....Consolidated Ashcroft Hancock Co.
Blowdown valves.....Edward Valve & Mfg. Co.
Non-return valves.....Edward Valve & Mfg. Co.
Turbine control valves on feed pumps.....Elliott Co.
Stop and check valves in feed lines.....Edward Valve & Mfg. Co.
High-pressure valves.....Walworth Co.
Medium-pressure valves.....Walworth Co. & Crane Co.
Low-pressure valves.....Crane Co.
Reducing valves.....Mason-Neilan Regulator Co.

PIPING, TRAPS AND STRAINERS:
Piping contractor.....R. M. Parsons Co.
Pipe insulation.....Plant Rubber & Asbestos Works
Expansion joints.....E. B. Badger & Sons Co.
High- and low-pressure traps.....Armstrong Machine Works

FEEDWATER SYSTEM:
Water columns.....Reliance Gauge Column Co.
Feedwater regulators.....Bailey Meter Co.
Excess-pressure regulators.....Mason-Neilan Regulator Co.
Boiler-feed pumps, 2; cap. each 240 g.p.m.; 1315-ft. head.....Worthington Pump & Mach. Co.
Feed-pump drive, 117-hp., 3550-r.p.m. turbine.....Elliott Co.
Feed-pump governors.....Mason-Neilan Regulator Co.
Evaporators, 1; 878 sq. ft.....Foster Wheeler Co.
Evaporator condensers.....Foster Wheeler Co.
Steam-jet air pumps.....Foster Wheeler Co.
Evaporator-pump.....Worthington Pump & Mach. Co.
Condenser for 15-lb. steam, 3950 sq. ft.....Foster Wheeler Co.
Evaporator-pump.....Worthington Pump & Mach. Co.
Makeup-water pumps.....Worthington Pump & Mach. Co.
Makeup-water-pump drive, turbine.....Elliott Co.
Feedwater deaerating heater.....Elliott Co.
Deaerator control.....Mason-Neilan Regulator Co.
Makeup-water heater.....Elliott Co.
Continuous-blowdown equipment.....Edward Valve & Mfg. Co.
Water-purification plant.....Permutit Co.
Feedwater treatment.....Dearborn Chemical Co.

METERS:
Boiler meters and control board.....Bailey Meter Co.
Boiler meters.....Bailey Meter Co.
Steam flowmeters.....Bailey Meter Co.
Feedwater flowmeters.....Bailey Meter Co.
Steam pressure and temp. recorders.....Bailey Meter Co.
Boiler-load indicators.....Bailey Meter Co.
Steam-pressure gages, indicating.....Foxboro Co.
Water-pressure gages, indicating.....Foxboro Co.
Oil-pressure gages, indicating.....Foxboro Co.
Thermometers, industrial.....Taylor Instrument Co.
Temperature recorders.....Bailey Meter Co.
Pyrometers.....Bailey Meter Co.
Draft gages.....Bailey Meter Co.
Water-circulating pumps, 6; cap. each, 4000 g.p.m.; total dynamic head 277 ft.....Worthington Pump & Mach. Co.
Water-circulating-pump turbines, cap. each, 330 hp.; operating on 450-lb., 560-F steam and exhausting at 150 lb.....Elliott Co.
Automatic desuperheater control.....Mason-Neilan Regulator Co.

COLUMBIA

Topping capacity increased by second 900-lb., 750-F boiler and 6,250-kw. turbine exhausting at 140 lb. and 450 F to process; bleed at 400 lb. Max. continuous steaming capacity increased over identical boiler installed in 1936 by using completely water-cooled furnace with slag-drip ledge tubes

COLUMBIA Chemical Division of Pittsburgh Plate Glass Co., Barberton, O., in continuing its modernization plan started in 1935, has added a second high-pressure boiler supplying 900-lb., 750 F steam to a 6,250-kw. turbine, exhausting at 140 lb. and 450 F with provisions for bleeding at 400 lb.

The first boiler and turbine unit went into service in July, 1936 (see Nov., 1936 *Power*, page 584), and has met expectations with a high percentage of reliability—exceeding 95% actual steaming time. The turbo-generator, based upon metered steam flows and switchboard electrical data, has surpassed the manufacturer's guarantee. The boiler was designed for 85.7 and 84.4% efficiencies at steaming rates of 125,000 and 180,000 lb. of steam per hr. respectively. These efficiencies are met in ordinary operation with a normal decline of from 1½ to 2% over a 3-month run due to increased temperatures. Recently the boiler was kept on the line for over 2,500 hours with an average load exceeding 155,000 lb. of steam per hr. (approximately 360% rating) damaging only refractories above inclined side-wall tubes at the stoker line.

Items of note in operation of the first unit are the low outage incurred, marked savings over low-pressure operation, extremely low auxiliary power requirements, and dependability of valves. Even though all blowdown valves are blown at least once a day and main valves three times a day, valves still drop tight after a year's service.

Turbine

In selecting equipment for the 1937 extension, plant engineers decided, in view of performance of the first high-pressure unit, to select a duplicate of the turbine unit. This is a Westinghouse 6,250-kw., 3,600-r.p.m., 140-lb. back-pressure turbine bled at 400-lb. (one of the highest bleed pressures in use) driving a 6,250-kva., 3-phase, 60-cycle, 3,600-r.p.m. alternator. Steam-generating equipment involved some changes to obtain greater steaming capacity in the same building space.

The first problem was to increase capacity of the fuel-burning equipment, as the first unit has a normal combustion rate of 41 lb. per sq. ft. of projected grate area per hr. (approximately 50 lb. maximum) with the general run of Ohio No. 8 coal. When the second unit was ordered it was felt that water-cooled underfeed stokers had been developed to the point of justifying the additional cost.

The stoker has 13 retorts, 63 thin tuyeres, a projected grate area of 430 sq. ft., and is driven by a 15-hp. d.c. motor. At max. continuous rating, burning rate will be 45 lb. per sq. ft. of projected grate area per hr. with a maximum rate of approximately 60 lb. per sq. ft. Stoker cooling surface consists of 52 tubes rising up from a header located above the front aprons to form the clinker-pit front wall. Two tubes in each retort bend in under bottom pusher to the header in the plenum chamber. Other tubes follow up the tuyere stacks on top of tuyeres.

Zoned air control is again employed. 42 venturi boxes with damper-flow control are arranged in three 14-box rows across the front, middle and rear zones of the stoker and are connected to three 14-pointer differential draft gages on the panel board. Each damper is manually controlled from the panel board by an air leak-off changing pressure in a sylphon bellows operating damper mechanism. Extension grate area is also divided into four separate zones across the stoker connected to a 4-pointer differential draft gage on the control panel with the same type of damper control. Furthermore, provision is made for both front- and rear-wall admission of overfire air in controlled amounts.

Steam-Generating Unit

B.&W. boiler has a few minor changes from previous one to increase max. continuous rating from 150,000 to 200,000 lb. per hr. with a 225,000-lb. per hr. 4-hr. peak capacity. Steam conditions are the same: 900 lb. per sq. in. and 750F. Principal difference is completely water-cooled furnace with slag-drip ledge tube along each side wall parallel to and about 3 ft. above stoker line.

In the older unit, deterioration of air-cooled refractories in side walls limited average rate of heat release to approximately 24,000 B.t.u. per cu. ft. of furnace volume. Water-cooled side walls were selected to overcome this difficulty and to allow average rates of heat liberation of 29,000 to 30,000 B.t.u. with a maximum of 34,000.

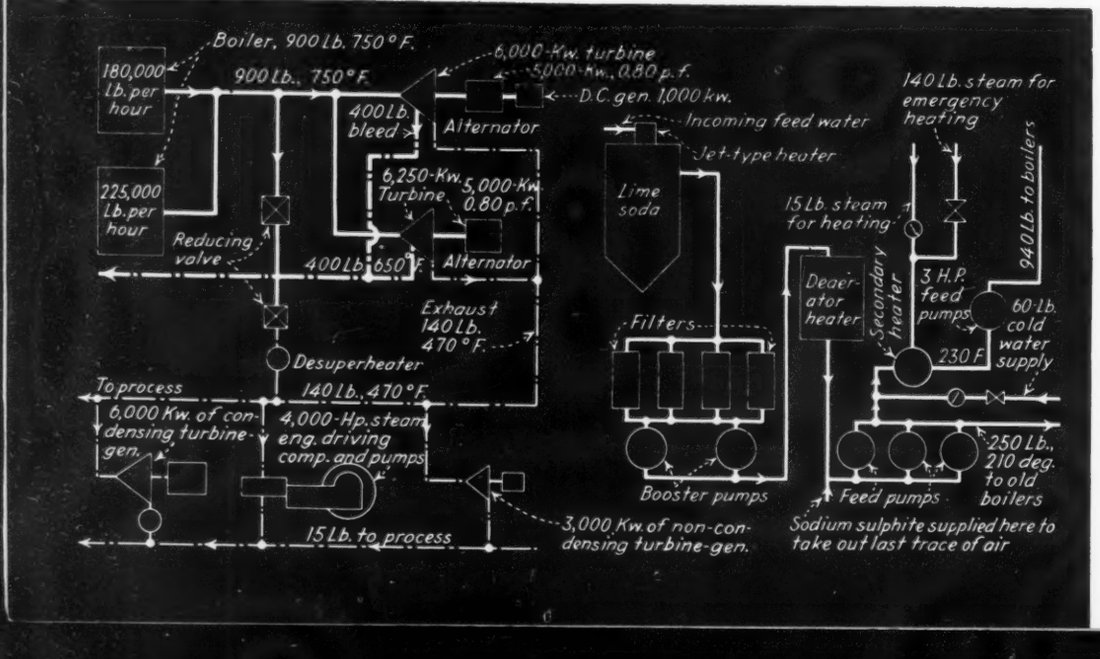
Lower half of the bridge wall and top and bottom side-wall sections are covered with Bailey bare blocks. Remainder of water-wall surface is bare-tube construction. The drip-ledge tube on each side wall is 3.25 in. in outside diameter and is swedged to 2.5 in. where it goes between side-wall tubes.

Proportions of the air heater and economizer surface were recommended by the boiler manufacturer to give the most economical heat-recovery surface for a 375 F stack temperature at 200,000 lb. per hr. Economizer is about half size of the one in the older unit. Air heater is designed to supply 310 F combustion air to the stoker.

Proportions of heat-absorbing surface are given in the table:

Boiler	35.8%
Superheater	12.5%
Water walls	5.6%
Stoker cooling	1.7%
Economizer	9.4%
Air preheater	35.0%

Flow diagrams. Features: (left) 6,250-kw. turbine bleeds at 400 lb. and exhausts at 140 lb. (right) Feedwater taken from 250-lb. treated feedwater header



Feedwater Equipment

Fans and feed pump for the new unit have non-condensing turbine drives because of process requirements for low-pressure steam and flexibility of turbine speed control. Feed pumps for high-pressure boilers are operated as units of one pump to each boiler through separate feed lines without any form of regulating valves. Boiler-water level is maintained automatically by controlling pump speed through an air-operated control attached to the water-level recorder transmitting pressure to a diaphragm-top throttle valve at the pump turbine. Due to absence of feed-line regulating valves, only a 75-lb. differential pressure is required at 180,000 lb. per hr. between pump discharge and boiler drum pressure, representing the feed-line and economizer-friction drop and the difference in elevation.

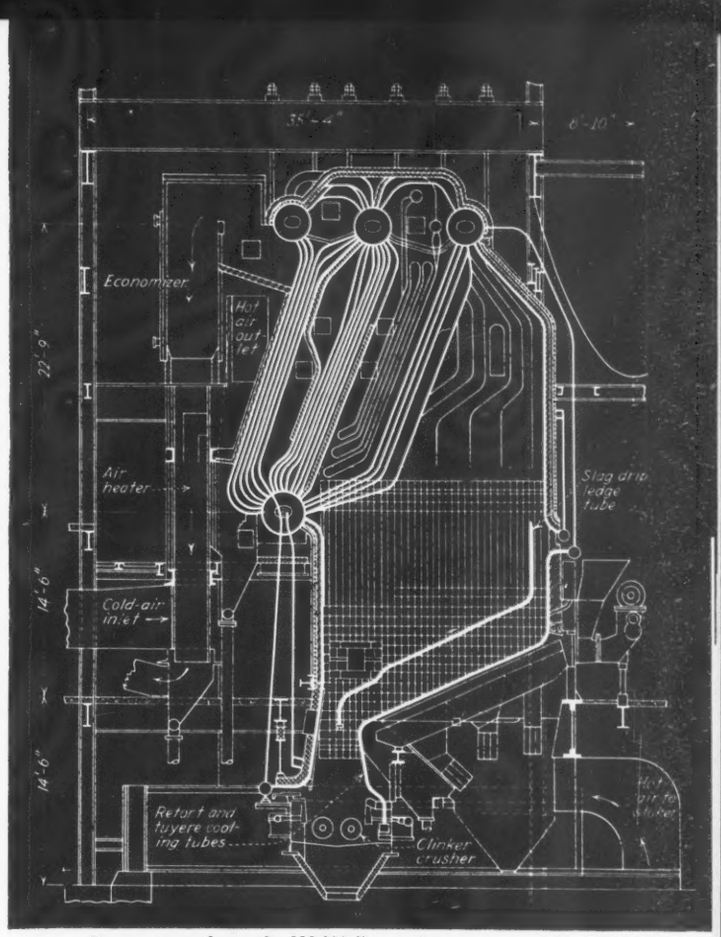
Former 250-lb. feedwater header to low-pressure boilers supplies suction of high-pressure feed pumps through a closed heater using 140-lb. steam. This increases feedwater temperature from 230 to 325 F.

An emergency 60-lb. cold-water line is tied into the system by means of a check valve to cut in automatically in case of failure of normal water-supply. Actual tests have proven that this can be done safely until other provisions are made to carry the load.

From superheater outlet to quick closing valve on the turbine, the steam header (350 ft. long) has all connections welded. Non-return valves are welded to superheater outlets. Steam flowmeters and division valves are also welded into the header. All welds are V-type butt, with a chill ring inside the pipe.

Operation is controlled from a single centrally-located panel board. In addition to the automatic combustion-control master, complete metering equipment is provided. Coal is weighed from overhead bunkers to the stoker hoppers by a weigh larry. Continuous data collected along with frequent flue-gas analysis affords continuous operation under practical test conditions at all times.

The new section of the plant went into operation about September 1—eleven months after first contracts were let—and was designed by the local engineering staff of Columbia Chemical Division.



Steam-generating unit: 225,000 lb. per hr. max capacity (4-hr. period) at 900 lb. and 750 F

PRINCIPAL EQUIPMENT FOR NEW UNIT

Columbia Chemical Div., Pittsburgh Plate Glass Co.

Boiler, Stirling, 45 tubes wide.....Babcock & Wilcox Co.
Boiler heating surface, 15,147 sq. ft.; waterwall surface (without stoker cooling) 2,380 sq. ft., max. continuous steaming capacity 225,000 lb. per hr.; working pressure, 900 lb. per sq. in.; total steam temperature, 750 F; furnace volume 9,200 cu. ft.; max. B.t.u. liberated per hr. per cu. ft. of furnace volume, 34,000.
Superheater, 5,310 sq. ft.....Babcock & Wilcox Co.
Economizer, 3,960 sq. ft.....Babcock & Wilcox Co.
Air heater, (tabular), 14,800 sq. ft.....Babcock & Wilcox Co.
Steam scrubber.....Babcock & Wilcox Co.
Soot blowers.....Diamond Power Specialty Corp.
Boiler setting, sectionally supported.....H. M. Detrick Co.
Furnace heat insulation.....Philip Carey Co.

COMBUSTION EQUIPMENT:

Stoker, one Taylor underfeed water-cooled with zoned air control, projected grate area, 430 sq. ft.....American Engineering Co.
Stoker drives, adjustable-speed d. c. motors
Crocker-Wheeler Elec. Mfg. Co.
Clinker crushers with Hele-Shaw hydraulic drives
American Engineering Co.
Ash hoppers.....Allen-Sherman-Hoff Co.
Forced-draft fan, 95,000 c.f.m. at 80 F and 9-in. static pressure
American Blower Co.
Forced-draft-fan drive, 200-hp. geared steam turbine
DeLaval Steam Turbine Co.
Induced-dratt fan, 163,500 c.f.m. at 435 F and 17-in static pressure
American Blower Co.
Induced-draft-fan drive, 600-hp. geared steam turbine
DeLaval Steam Turbine Co.
Coal-handling equipment extension.....Link Belt Co.
Weigh larry.....Link Belt Co.

CONTROL AND VALVES:

Water columns.....Yarnall Waring Co.
Feedwater regulators.....Bailey Meter Co.
Automatic combustion control.....Republic Flow Meters Co.
Safety valves.....Crosby Steam Valve & Gage Co.
Blowoff valves.....Yarnall Waring Co.
Non-return valves.....William Powell Co.
Atmospheric relief valves.....Atwood & Morrill Co.
Extraction non-return valve.....Schutte & Koerting Co.
Feedwater valves.....William Powell Co.
High- and low-pressure valves.....William Powell Co.
Reducing valves.....Schutte & Koerting Co.
Desuperheater and control.....Schutte & Koerting Co.
Electric valve operators, Limitorque.....Philadelphia Gear Works

PIPING AND TRAPS:

Pipe heat insulation.....Philip Carey Co.
Expansion joints.....E. B. Badger & Sons Co.
Traps.....Yarnall Waring Co.
Piping contractor.....Pittsburgh Piping & Equipment Co.

FEEDWATER SYSTEMS:

Boiler-feed pump, 8-stage, 550-g.p.m., suction 250 lb., discharge, 1,050 lb. sq. in.....Ingersoll-Rand Co.
Drive, 370-hp. turbine.....DeLaval Steam Turbine Co.
Booster pump, 1,200-g.p.m., 50-ft. head, turbine driven
DeLaval Steam Turbine Co.
Auxiliary feedwater heater, 200,000 lb., from 225 to 325 F.
C. H. Wheeler Mfg. Co.
Deaerator regulator control.....Taylor Instrument Companies
Feedwater treatment, Hall system.....Hagan Corp.

METERS:

Boiler meters.....Bailey Meter Co.
Steam flowmeters.....Bailey Meter Co.
Feedwater-level recorders.....Bailey Meter Co.
Boiler-pressure gages.....Crosby Steam Valve & Gage Co.
Turbine-pressure gages.....Westinghouse Elec. & Mfg. Co.
Turbine-speed indicators.....James G. Biddle Co.
Pressure gages, recording.....Bailey Meter Co.
Temperature recorders.....Bailey Meter Co.
Temperature recorders, 7 pointer.....Leeds & Northrup Co.
Temperature recorders.....Taylor Instrument Companies
Thermometers, industrial.....Taylor Instrument Companies
Draft gages, 3 14-pointer, 1 4-pointer.....Ellison Draft Gage Co.
Flue-gas analyzer.....Ellison Draft Gage Co.

GENERATING UNITS:

One, 6,250-kw., 3,600-r.p.m. turbine designed for 850 lb. and 825 F; throttle conditions 825 lb., 750 F; extraction automatically at 400 lb., exhaust 140 lb. back pressure.Westinghouse Elec. & Mfg. Co.
Turbine connects directly to a 6,250-kva., 0.80 p.f., 3-phase, 60-cycle, 2,300-volt Westinghouse alternator.
Generator air coolers.....Westinghouse Elec. & Mfg. Co.
Turbine-oil coolers.....Westinghouse Elec. & Mfg. Co.
Turbine-oil purifying system.....S. F. Bowser & Co.
Oil pump.....S. F. Bowser & Co.
Switchboard and oil circuit breakers.....General Electric Co.
Transformers.....Allis Chalmers Mfg. Co.

FORD MOTOR

World's largest high-pressure power station, Rouge plant No. 1, now operates two 110,000-kw. H.P. condensing turbines (also a 15,000-kw. backpressure turbine) and three H.P. boilers. Evaporators on 15,000-kw. turbine exhaust permit byproduct-power generation without contamination of H.P. feed water

POWER plant No. 1, Rouge works of Ford Motor Company, Dearborn, Mich., the world's largest high-pressure steam power plant, has the largest individual H.P. turbines, largest H.P. boilers, and is the first American plant to use 900-F steam on a large scale.

The following tabulation omits the 30,000-kw., 240-lb. turbines, since one has just been removed and the others will be shortly, leaving an exclusively high-pressure turbine plant. Units marked * are the subject of this article, with brief references to previous units and those on order:

H.P. Turbines

No 1-2—110,000-kw., 1215-lb., 750-F, condensing, started 1931
*No. 3-4—110,000-kw., 1215-lb., 910-F, condensing, started 1936
No. 5—15,000-kw., 1215-lb., 910-F, backpressure, started 1936
No. 6-7—110,000-kw., 1215-lb., 925-F, condensing, to start in 1939

H.P. Boilers

Nos. 1 & 2—700,000-lb.-per-hr. each, 1350-lb., 760-F, started 1931
*No. 3—900,000-lb.-per-hr., 1350-lb., 915-F, started 1936.
No. 4—900,000-lb.-per-hr., 1350-lb., 930-F, to start in 1939.

Double numbering of condensing turbines covers the H.P. and L.P. cylinders. Turbine and boiler now on order practically duplicate units started in 1936, except for slightly higher steam temperature. Four old 240-lb. boilers have been retained to operate turbines driving blast-furnace blowers and to serve any demands for factory steam not supplied by evaporators on exhaust of the 15,000-kw. turbine.

On a stupendous scale, Ford's load is typical of the metal-working industries in that the ratio of power load to process and heating load is high. This calls for high pressure to generate all possible power as a by-product. Yet, even with highest commercial pressures, process heat can produce only a fraction of power demand. The rest must be generated in condensing turbines. Here, again, fuel economy calls for high pressure. Ford chose 750 F, with (steam) reheating, for 1931 because higher steam temps. were not then commercial.

Conservative in temperature only, the 1931 unit was a single jump from 240 lb. and 30,000-kw. to 1,215-lb. and 110,000-kw. The turbine was split into two 55,000-kw. cylinders, H.P. cylinder mounted directly on L.P. Generators, also, were stacked vertically, and in a common housing.

Technical progress during the depression made it feasible to use H.P. steam at 900 F. This eliminates need for reheating and was therefore selected for the next 110,000-kw. unit. A 15,000-kw. H.P. backpressure turbine was installed to generate all possible by-product power from process-steam load. Entire exhaust of the 15,000-kw. unit goes to a battery of evaporators. There the 240-lb. exhaust produces 180-lb. factory steam and is itself condensed and returned as pure feedwater for H.P. boilers.

The new (1936) G.E. 110,000-kw. turbine is practically a duplicate of the first unit, except for the higher steam temperature. The first turbine was supplied by two 700,000-lb.-per-hr. boilers. Their success suggested another daring forward step, so steam for the new turbines was supplied by a single Combustion boiler guaranteed to deliver 900,000-lb. per hour continuously at 1,350 lb. and 915 F. It has actually been operated at over a million pounds on test.

Heat balance is simple, and largely explained by the foregoing. The 110,000-kw. turbine bleeds at 4 points for feed heating. The 15,000-kw. unit exhausts its *heat* to the factory. Cross-over connections pool H.P. steam so that any boiler can feed any turbine. Feed temperatures, etc., are on the flow diagram.

Steam-Generating Units

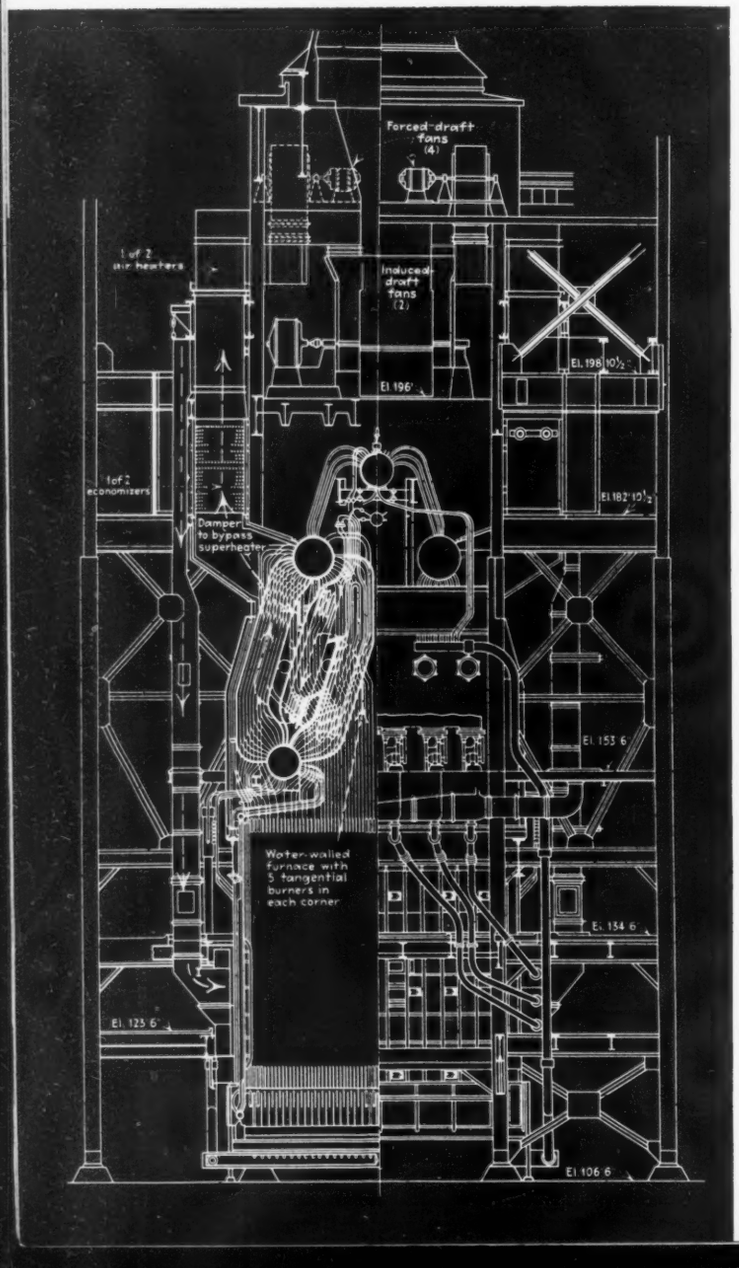
The steam-generating unit of 1936 has a maximum continuous capacity of 900,000-lb.-per-hr. at 1,350 lb. (drum pressure) and 915 F (superheater outlet). The 5-drum, double-set boiler has two superheaters, two fin-tube economizers and two plate-type air heaters.

The 30,000-cu.ft. furnace, completely walled with fin tubes, operates "dry bottom" with a full-load heat liberation of 34,000 B.t.u. per cu.ft. per hr. (14,400-B.t.u. coal, 2,700-F ash fusion).

Thermostatically-controlled bypass dampers are set to limit superheat mechanically, but load-steam-temperature characteristic is so flat that this control has not been used.

In each corner of the furnace are five "tangential" burners, the middle three for pulverized coal, the upper for coke-oven gas and the lower for

Steam-generating unit: 900,000 lb. per hr. max. capacity at 1350 lb. and 915-F



blast-furnace gas. Gas is fired mainly week-ends and when starting up.

All boiler auxiliaries of the 1936 addition are motor driven. Feedwater is handled by two 2,535-g.p.m. booster pumps discharging into two 2,800-g.p.m. feed pumps. Cross-over lines permit paralleling motor-driven booster and feed pumps of the 1936 installation with those of 1931 (2 motor-driven and 1 steam-driven).

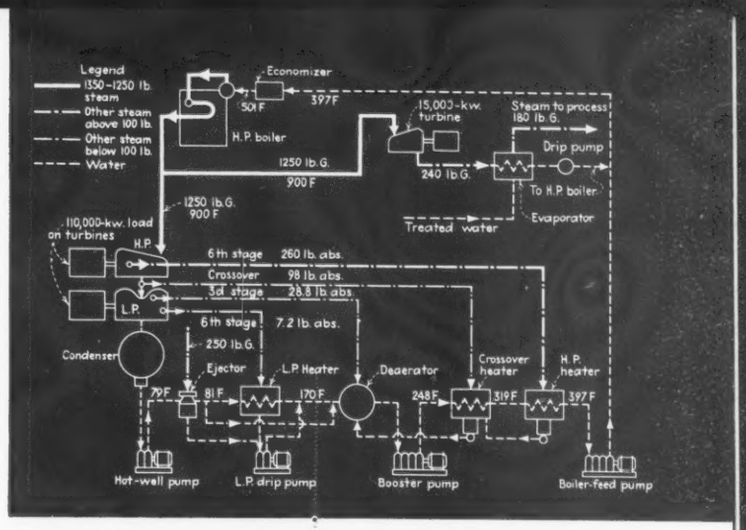
In the new main unit, throttle steam is 1215 lb. and 910 F. Exhaust: 29-in. vacuum. Bleeds at 6th H.P. stage, crossover, 3rd L.P. and 6th L.P. stages. Throttle steam rate is 8.32 lb. at half load and 8.40 lb. at full load. Condenser steam rates are 6.43 and 6.03 lb. for half and full load, resp.

Generator is in two 55,000-kw. elements, each 62,500 kva., 0.8 p.f., 60 cycle, 3 phase, 13,800 volts.

The 15,000-kw. unit takes steam at 1215 lb. and 910 F, exhausts to process evaporators at 240-lb. Running at 3,600 r.p.m., it drives a 19,000-kva., 0.8-p.f., 60-cycle, 3-phase, 13,800-volt generator.

Valves and piping for high-pressure, high-temperature steam are of carbon-molybdenum steel. Piping is "all-welded" by the d.c. metallic arc process, with coated electrodes, with streamlined chill rings. Joints were stress-relieved by an induction-type collar (200 kva.).

Availability of all H.P. turbines at Rouge 1 has averaged 98.5% since 1931. The 1½% may be charged off to early slight difficulties with the steam reheater on No. 1-2. No H.P. turbine proper has been down at any time. The entire H.P. plant has had 100% availability since 1935.



Flow diagram. Feature: All process steam is generated at 180 lb. G in evaporators served by exhaust of 1,500-kw. unit

PRINCIPAL POWER-PLANT EQUIPMENT

Ford Motor Co., River Rouge Plant, Detroit, Mich.

(Table refers exclusively to equipment associated with the 110,000-kw- and 15,000-kw. units put into operation in 1936)
Consulting Engineers ..... Ford Motor Co. Engrs.
Boilers and waterwalls ..... Combustion Engineering Co.
Boiler, heating surface, 30,000 sq.ft.; waterwalls, 9,500 sq.ft.; max. continuous steaming cap., 900,000 lb. per hr.; working press., 1,350 lb. G.; total steam temp., 915 F.; furnace volume, 30,000 cu.ft.; max. B.t.u. liberated per cu.ft. per hr. 34,000
Superheater, 21,940 sq.ft. ..... Combustion Engineering Co.
Economizers, 2; 25,300 sq.ft. total surface.. Combustion Engineering Co.
Air heaters, 2; 86,000 sq.ft total surface.. Combustion Engineering Co.
Boiler and furnace settings ..... Combustion Engineering Co.
Boiler heat insulation
Philip Carey Co., General Refractories Co. and Johns Manville
Apexiorizing ..... Dampney Co. of America
Boiler ducts and breechings ..... Combustion Engineering Co.
Stack, self-supporting steel ..... American Bridge Co.
Structural steel contractor ..... Ford Motor Co.

COMBUSTION EQUIPMENT:
Automatic combustion control ..... Bailey Meter Co.
Sootblowers ..... Diamond Power Specialty Corp.
Pulverized-coal burners, 12 per boiler; cap. each, 8,000 lb. per hr.
Combustion Engineering Co.
Gas burners, 8 per boiler (4 blast-furnace and 4 coke-oven-gas)
Combustion Engineering Co.
Forced-draft fans, 4 per boiler; cap. each, 70,000 c.f.m.; static press. 10.2 in.; turbovane type, vane control ..... B. F. Sturtevant Co.
Forced-draft-fan-drive, 1150/1750-r.p.m., 2,300-volt, 2-speed induction motor ..... General Electric Co.
Forced-draft-fan motor control ..... Bailey Meter Co.
Induced-draft fans, 2 per boiler; cap. 260,000 c.f.m.; static press. 10.2 in. ..... B. F. Sturtevant Co.
Induced-draft-fan drive 885/588-r.p.m., 2,300-volt, 2-speed induction motor ..... Crocker Wheeler Elec. Mfg. Co.
Induced-draft-fan motor control ..... Bailey Meter Co.

VALVES:
Safety valves ..... Consolidated Ashcroft Hancock Co.
Blowdown valves ..... Yarnall-Waring Co.
Non-return valves ..... Schutte & Koerting Co.
Stop and check valves in feed lines ..... Chapman Valve Mfg. Co.
Motor-operated valves ..... Chapman Valve Mfg. Co.
Low-pressure valves
Lunkenheimer Co., Wm. Powell Co. and Chapman Valve Mfg. Co.
High-pressure valves
Edward Valve & Mfg. Co. and Chapman Valve Mfg. Co.
Extraction non-return valves ..... Chapman Valve Mfg. Co.
Atmospheric relief valves ..... Worthington Pump & Mach. Corp.

PIPING, TRAPS AND STRAINERS:
Piping contractor ..... Grinnell Co.
Pipe insulation ..... Philip Carey Co. and Johns Manville
High-pressure traps ..... Strong Trap Co.
Low-pressure traps ..... Trerice Co.

FEEDWATER SYSTEM:
Water columns ..... Reliance Gauge Column Co.
Feedwater regulators ..... Bailey Meter Co.
Boiler-feed pumps, 2; cap. each, 2,800 g.p.m.; 2,300-ft. head
Worthington Pump & Mach. Corp.
Drive, 1,860-hp., 1775/1525-r.p.m., induction motor
General Electric Co.
Feed-pump-motor controllers ..... Bailey Meter Co.
Drive, 1775/1525-r.p.m., induction motor ..... General Electric Co.
Boiler-feed booster pump drive, 1775/1525-r.p.m., induction motor
General Electric Co.
Feedwater purification equipment ..... Cochrane Corp.
Feedwater deaerating heater ..... Elliott Co.
Feedwater heaters ..... Foster Wheeler Corp.
Evaporators (for process steam) ..... Foster Wheeler Corp.
Feedwater treatment (Buromin) ..... Hall Laboratories

METERS:
Boiler meter and control board ..... Bailey Meter Co.
Turbine meter and control board ..... Republic Flow Meters Co.
Boiler meters ..... Bailey Meter Co.
Steam flowmeter ..... Bailey Meter Co.
Gas-air flowmeters ..... Bailey Meter Co.
Steam-flow pressure and temp. recorders ..... Bailey Meter Co.
Feedwater flowmeters ..... Bailey Meter Co.
Boiler-water-level indicators ..... Bailey Meter Co.
Boiler-water-level recorders ..... Bailey Meter Co.
Boiler-load indicators ..... Bailey Meter Co.
Steam-pressure gages, indicating.. Consolidated Ashcroft Hancock Co.
Water-pressure gages, indicating. Consolidated Ashcroft Hancock Co.
Gas-pressure gages, indicating ..... Bailey Meter Co.
Turbine-pressure gages, indicating ..... Foxboro Co.
Turbine-pressure gages, recording ..... Republic Flow Meters Co.
Turbine-speed indicator ..... General Electric Co.
Vacuum column ..... Consolidated Ashcroft Hancock Co.
Thermometers, industrial ..... Trerice Co. and Taylor Instrument Cos.
Temperature recorders ..... Bailey Meter Co.
Temperature recorders, multiple-point ..... Bailey Meter Co.
Generator temperature recorder
Leeds & Northrup Co. and Republic Flow Meters Co.
Pyrometers ..... Leeds & Northrup Co.
Draft gages ..... Bailey Meter Co.
Draft gages, multiple point ..... Bailey Meter Co.
CO_2 indicator ..... Bacharach Industrial Instrument Co.

BACKPRESSURE GENERATING UNIT:
One 15,000-kw. 3,600-r.p.m. turbine; throttle steam conditions, 1,250 lb. G., 910 F; exhausts to process steam evaporators at 250 lb. G. ..... General Electric Co.
Turbine connects directly to 19,000-kva., 3-phase, 60-cycle generator
General Electric Co.

MAIN GENERATING UNIT:
One 110,000-kw., 1,800-r.p.m., vertical-compound steam turbine; throttle steam conditions, 1,250 lb. G., 910 F.; automatic extraction at 225-86-28-7.4 lb.; exhaust 0.50 lbs abs... General Electric Co.
High- and low-pressure elements of turbine are separately connected to 62,500-kva., 0.8-p.f., 3-phase, 60-cycle generators
General Electric Co.
Generator air cooler ..... General Electric Co.
Oil cooler ..... Schutte & Koerting Co.
Oil purifier ..... DeLaval Steam Turbine Co.
Condenser, 73,000 sq.ft. ..... Worthington Pump & Mach. Corp.
Deaerating hotwell ..... Elliott Co.
Circulating pumps, 2; 58,700 g.p.m.. Worthington Pump & Mach. Corp.
Circulating-pump-driving motor, 325-hp., 300-r.p.m., 2,300-volt
General Electric Co.
Condensate pumps, 2; 1,800 g.p.m.. Worthington Pump & Mach. Corp.
Condensate-pump-motor drive, 149-hp., 900-r.p.m., induction motor
General Electric Co.
Vacuum pump, ejector-type ..... Worthington Pump & Mach. Corp.
Exciters, turbine-driven ..... General Electric Co.
Exciters, motor generators ..... General Electric Co.
Station switchboard ..... General Electric Co.
House switchboard ..... General Electric Co.
Station transformers
Westinghouse Elec. & Mfg. Co. and General Electric Co.
Station-lighting transformers ..... Allis-Chalmers Mfg. Co.
Oil circuit breakers
Westinghouse Elec. & Mfg. Co. and General Electric Co.
Air circuit breakers, I.T.E.
Circuit Breaker Co. and Westinghouse Elec. & Mfg. Co.
Busbars .... Westinghouse Elec. & Mfg. Co. and General Electric Co.
High-voltage cables.. Anaconda Wire & Cable Co. & General Cable Co.
Station auxiliary and lighting conductors ..... General Cable Co.
Air compressors .... Sullivan Machinery Co., Bury Air Compressor Co., Ingersoll-Rand Co., Worthington Pump & Mach. Corp., and Chicago Pneumatic Tool Co.
Electric elevators ..... Otis Elevator Co.
Travelling crane.. Shaw Crane & Hoist Co. and Harnischfeger Corp.

PUBLICKER

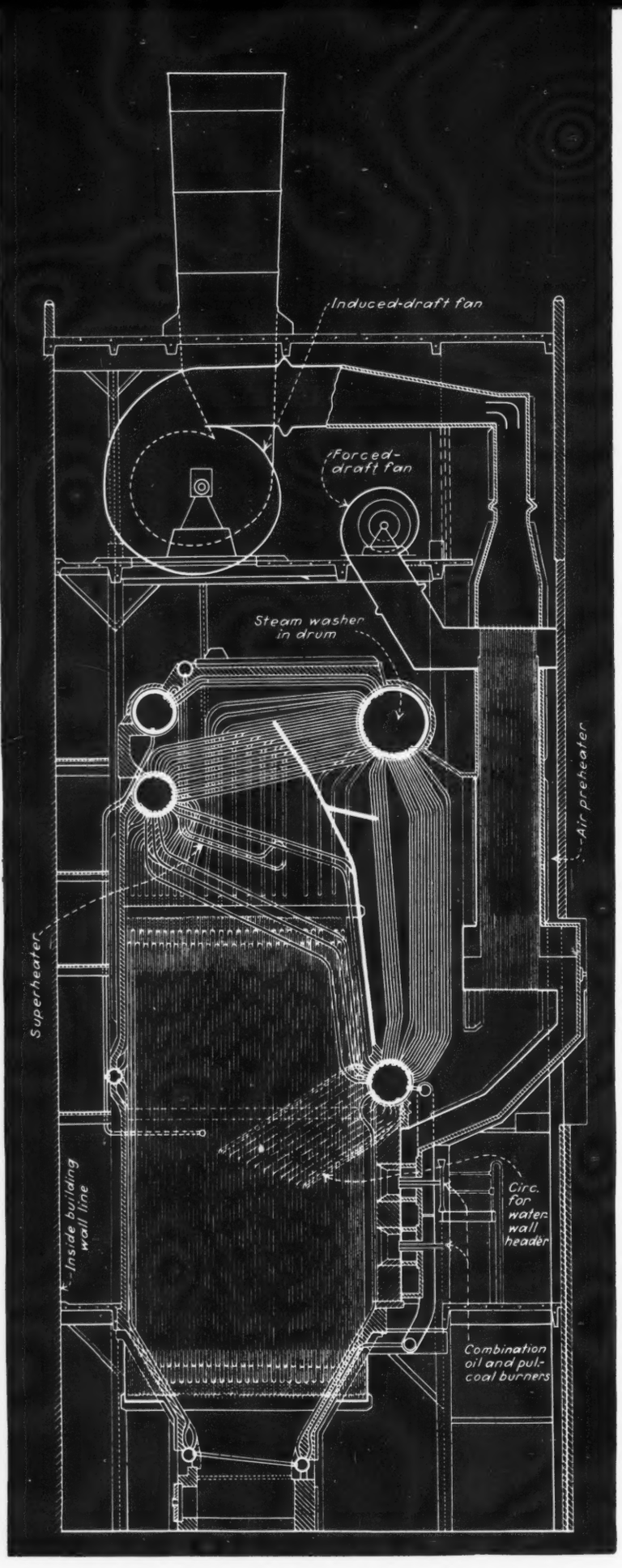
Increasing process-steam demands met by additional steam-generating units is Publicker's story. The 275,000-lb.-per-hr. steam unit now going in is part of a program to supply steam, with an eye to the future when power may also be generated

THE PUBLICKER Commercial Alcohol Co. plant at Bigler St., Philadelphia, produces commercial alcohol, dry ice and chemicals. The main industrial processes are fermentation of molasses to produce ethyl and butyl alcohol and acetone. Fermented mashes contain mainly water with about 2 to 7% solvents, depending on type of fermentation. Recovery of these solvents necessitates much steam, both high- and low-pressure, depending on the type of still used. Until 1933, all the company's plants could handle the business done in commercial alcohol. From then on, all of it had to come from the Bigler St. plant. The busy season for alcohol and solvents is in the fall, and last year was the peak year so far.

In terms of steam demand, this meant that over a period of three months a load of 260,000 lb. per hr. was repeatedly handled. More steam could have been used, but the four existing boilers could not furnish enough. Three steam locomotives were rented for portable boilers to help meet the load. Construction of the new steam unit corrects this condition.

Existing Plant

The existing plant consists of two 6,000-sq. ft. and two 9,000-sq. ft. Badenhausen boilers, furnishing steam at 150 lb. G and 50 F superheat. The first of these had underfeed stokers for a time, but now all four are oil fired. About two-thirds of the high-pressure steam produced is used in stills and for chemical manufacture; the remainder goes to turbine-driven auxiliaries. These turbines exhaust at 10 lb. G, which at present is used for heating in some stills and for feedwater heating in an open heater. Makeup, barring any line drips, is 100%. It is obtained from city water mains and is treated in a Permutit system from which it goes to the open heater and then to boilers. The present plant also houses three air compressors, one turbine and two engine driven. Fuel-oil pumps, boiler-feed and several process-water pumps complete the plant.



Steam-generating unit: 275,000-lb. per hr. max. cont. capacity at 475 lb., 650 F. (At present operating at 150 lb. and 50 F superheat)

The new Riley steam-generating unit has a maximum continuous capacity of 275,000 lb. of steam per hr. at 475 lb. G and 650 F, and a completely water-cooled wall forming the furnace. Present plans call for operation at 150 lb. and 50 F superheat to supply process steam only. The boiler consists of four drums with bent tubes and a bank of convection superheater tubes. Gas, directed by a baffles across the tubes, passes through an air preheater and is then discharged through a stack by a turbine-driven induced-draft fan.

The stack is a square, metal, self-supporting type with a slight flare upwards, but is not the conventional venturi stack. Both induced- and forced-draft fans are at present mounted in the top of the unit, but provision is made to move the forced-draft fan and replace it with a fly-ash remover. One turbine-driven forced-draft fan supplies combustion air.

Firing

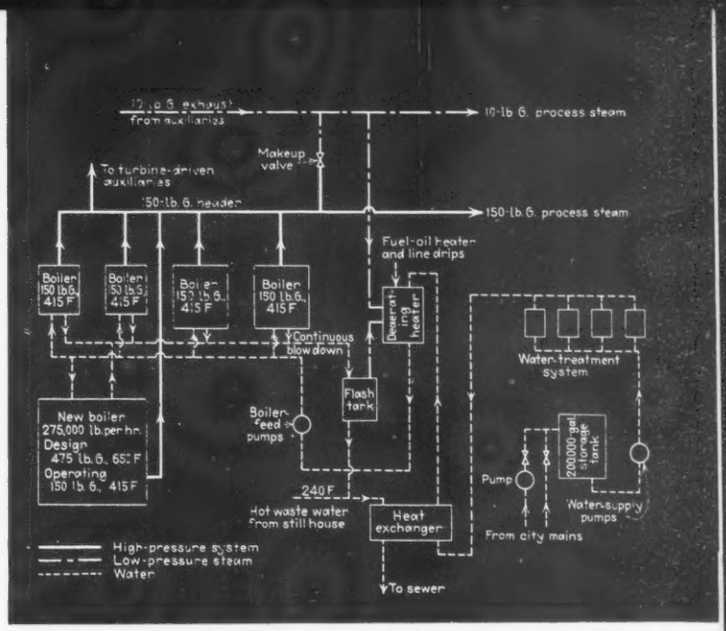
Six combination burners make it possible to burn both coal and oil, but at present, oil firing will be used because of existence of storage tanks and facilities for handling fuel oil. No coal-handling equipment of any type is installed and any expenditure for it was considered unwarranted as long as steam is for process only. Power generation in the future and a possible additional steam unit will make probable a change to pulverized coal firing.

The new steam unit is built against the outside wall of the existing plant, and for the present it will be bricked in. Adjacent to it is ground area for an additional unit, and back of these two locations is sufficient area for power equipment. Existing boilers are to be standby units for the present. Two went in in 1924 and two in '29.

Proposed operating cycle, when the unit now being built is completed, calls for additional equipment. Feedwater heating for new unit and for standby boilers is furnished by both deaerating heater and closed-type heat exchanger which are to be installed. The deaerating heater is to receive water from the heat exchanger, and steam at 10 lb. G from the auxiliary exhaust and from a flash tank to be put in with a continuous blowdown system. In the separation of alcohol in the stills, much hot water is discharged to the sewer. Before going there, it is combined with blowdown from the boilers and used in the closed heat exchanger to give preliminary heating to feedwater.

Feedwater comes directly from city mains and, depending upon city pressure, is either run or pumped by a motor-driven pump to a 200,000-gal. storage tank. Two rebuilt turbine-driven pumps take water from the tank and deliver it through the Permutit system from which it goes to heaters. Feedwater from the deaerating heater is taken by boiler-feed pumps to the boilers. An existing 1,200-g.p.m. turbine-driven pump is to be used in parallel with a new 1,500-g.p.m. similar unit.

Pumps now handling fuel oil will be scrapped and replaced by a fuel-oil pump set consisting of two turbine-driven fuel-oil pumps and two oil heaters. Both oil heaters and turbines will take 150-lb. steam, with the latter exhausting into 10-lb. headers while heater drip is taken to the deaerator heater.



Flow diagram. Feature: Steam all used for process

PRINCIPAL POWER PLANT EQUIPMENT

Publicker Commercial Alcohol Co., Phila., Pa.

Consulting Engineer ..... Sheppard T. Powell
Boiler and waterwalls ..... Riley Stoker Corp.
Boiler, 1; heating surface, 19,400 sq. ft.; water-walls, 9,000 sq. ft.; max. continuous steaming cap. 275,000 lb. per hr.; Working press., 150 lb. G; total steam temp. 415 F.; furnace volume, 15,600 cu. ft.; max. B.t.u. liberated per cu. ft. per hr., 21,300.
Superheater, 1,290 sq. ft. ..... Riley Stoker Corp.
Air heater, 28,000 sq. ft. ..... Riley Stoker Corp.
Boiler and furnace settings ..... Riley Stoker Corp.
Boiler heat insulation ..... Eagle Picher Lead Co.
Boiler ducts and breechings ..... Riley Stoker Corp.
Stack, self-supporting steel ..... Riley Stoker Corp.
Structural-steel contractor ..... S. H. Levin

COMBUSTION EQUIPMENT:
Automatic combustion control ..... Republic Flow Meters Co.
Soot-blowers ..... Bayer Soot Blower Co.
Combination oil and pulverized coal burners, 6 per boiler; cap. each, 60,000 lb. steam per hr. ..... Riley Stoker Corp. & Engineer Co.
Oil-burning assembly ..... Engineer Co.
Oil pumps, 2 ..... Quimby Pump Co.
Oil heaters, 2 ..... Griscom-Russell Co.
Oil-pump drive, 2 turbines ..... Coppus Engineering Corp.
Oil strainers ..... Elliott Co.
Oil-temperature regulators ..... Atlas Valve Co.
Oil-pressure governors, 2 ..... Leslie Co.
Oil-storage-tank pumps 2 ..... Union Steam Pump Co. & DeLaval Steam Turbine Co.
Forced-draft fan, 1; cap. 72,500 c.f.m. at 80 F.; static pressure 7.9 in. ..... American Blower Co.
Forced-draft-fan drive, 1 143-hp., 4,000-r.p.m. turbine with reduction gear ..... Moore Steam Turbine Co.
Induced-draft fan, 1; cap. 112,880 c.f.m.; static pressure 7.0 in. ..... American Blower Co.
Induced-draft-fan drive, 1; 280-hp. turbine with reduction gear ..... Moore Steam Turbine Co.

VALVES:
Safety valves ..... Consolidated Ashcroft Hancock Co.
Blowdown valves ..... Edward Valve & Mfg. Co.
Non-return valves ..... Golden Anderson Valve Specialty Co.
Stop and check valves in feed lines ..... Edward Valve & Mfg. Co.
High-pressure valves ..... Edward Valve & Mfg. Co.
Low- and medium-pressure valves ..... Jenkins Bros., Chapman Valve Mfg. Co., Lunkenheimer Co., Crane Co.
Makeup valve ..... Belfield Co.
Makeup-valve regulator ..... Brooke Engineering Co.

PIPING, TRAPS AND STRAINERS:
Piping contractor ..... Not yet selected
Pipe insulation ..... Not yet selected
Expansion joints ..... Not yet selected
High- and low-pressure traps ..... Not yet selected
Strainers ..... Not yet selected

FEEDWATER SYSTEM:
Water columns ..... Reliance Gauge Column Co.
Water-level recorder ..... Republic Flow Meters Co.
Feedwater regulators ..... Northern Equipment Co.
Excess-pressure regulators ..... Northern Equipment Co.
Boiler-feed pump, 1; cap. 1,500 g.p.m.; 550-ft. head ..... Ingersoll-Rand Co.
Feed-pump drive, 1; 247-hp.; 2,100-r.p.m. turbine ..... Moore Steam Turbine Co.
Feed-pump governors ..... Northern Equipment Co.
Water-supply pumps, 2; cap. 1,200 g.p.m.; 175-ft. head ..... DeLaval Steam Turbine Co.
Water-supply-pump drives, 2 turbines ..... DeLaval Steam Turbine Co.
Water-supply pump, 1; capacity 1,500 g.p.m.; 65-ft. head ..... Allis-Chalmers Co.
Water-supply-pump drive, 1; motor ..... Allis-Chalmers Co.
Feedwater-purification equipment ..... Permutit Co.
Feedwater deaerating heater ..... Cochrane Corp.
Feedwater heater ..... Griscom-Russell Co.
Continuous-blowdown equipment ..... Cochrane Corp.

METERS:
Steam-flow, air-flow meter ..... Bailey Meter Co.
Steam pressure and temp. recorders ..... Republic Flow Meters Co.
Feedwater flow recorder ..... Republic Flow Meters Co.
Blowdown meter ..... National Meter Co.
Boiler-feed-pressure recorder ..... Republic Flow Meters Co.
Steam-pressure gages, indicating ..... Republic Flow Meters Co. Crosby Steam Gage & Valve Co.
Oil-pressure recorder ..... Republic Flow Meters Co.
Oil-temperature recorder ..... Republic Flow Meters Co.
Oil-displacement meters ..... National Meter Co.
Temperature recorders, multiple point ..... Republic Flow Meters Co.
Draft gages, multiple point ..... Republic Flow Meters Co.
Smoke density indicator ..... Ess Instrument Co.

INDUSTRIAL RAYON

Industrial Rayon Corp. builds a brand new factory at Painesville, Ohio. Three 90,000-lb.-per-hr. boilers (725 lb.G and 780 F) serve three 5,000-kw. bleeder condensing turbines. Continuous process and factory use of condenser circulating-water heat gives almost pertect heat balance

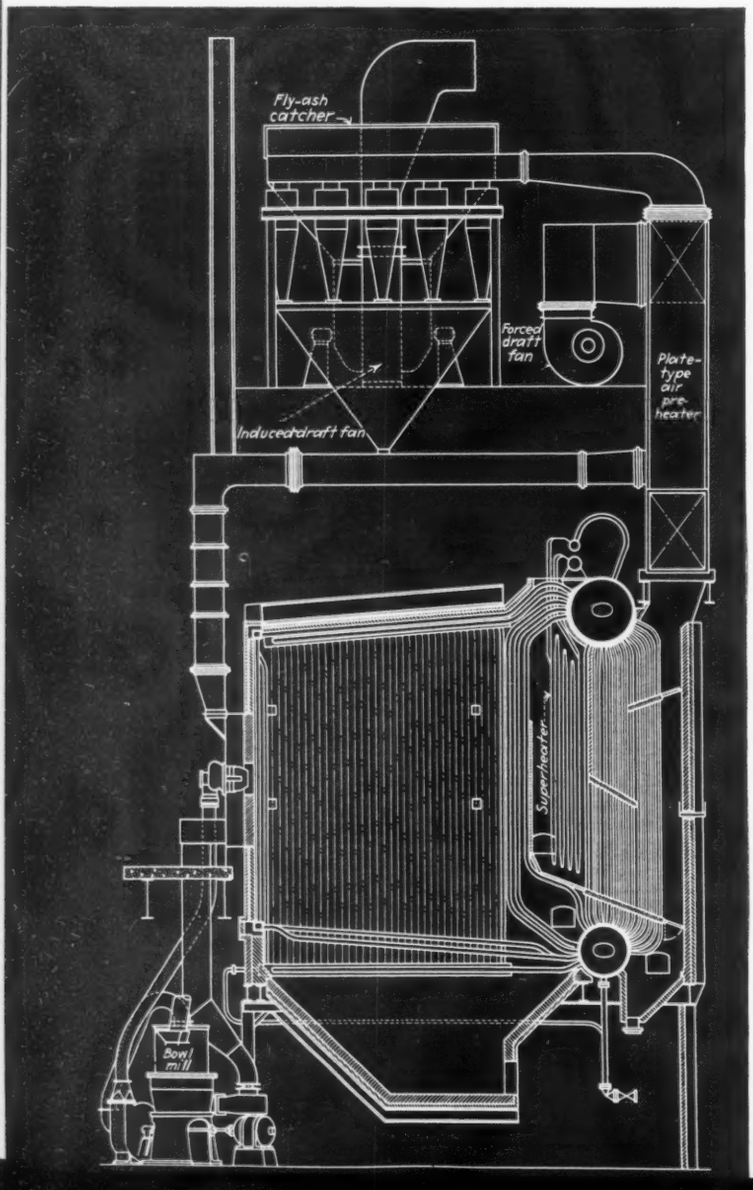
THE NEW Painesville factory of Industrial Rayon Corp., to begin operation next Spring, will cost eight to ten millions, employ eight or nine hundred workers, occupy a 500-acre tract, use most advanced manufacturing technique. H. B. Kline, vice-president, and L. J. Jordan, chief engineer, visited sites from Maine to California. They chose Painesville primarily because of good water, high-quality labor and nearness to materials and markets.

Pressure, Heat Balance

Ratio of heat demand to power demand is practically constant because the process is continuous. It requires power for refrigeration, air conditioning and machines, also process and heating steam at 15-lb. G. and great quantities of clean, soft water at about 105 F. This process-water requirement was a dominant factor in selecting heat balance and steam conditions. It led to condensing turbines bleeding at 15-lb., with circulating water treated and delivered to process. Vacuum is a secondary consideration. Circulating-water flow is regulated to maintain 105-F process.

For this arrangement, and existing steam and power loads, turbine throttle conditions of 650 lb. and 750 F give ample power and 50-deg. superheat at 15-lb. bleed.

Steam-generating units: three 90,000-lb.-per-hr. max. continuous capacity at 725 lb. and 780 F



The hookup is novel in many respects, notably on the water side. It is dominated by the treatment and heating of process water. Electricity is a byproduct of 15-lb. steam and process water. Boiler makeup is taken from the treated process-water supply.

Steam from three 90,000-lb. per hr. (max. continuous) Combustion steam - generators leaves superheater at 725 lb. and 780 F, enters turbines at 650 lb. and 750 F (both controlled), expands to 15 lb., bleed and to condenser pressure of about 1.0 lb. abs. Other high-pressure steam is expanded through auxiliary turbine drives to 15 lb. The flow diagram shows also a "reducer" to 15 lb. This has not been purchased; it may prove better to avoid the complication and expense of a reducing valve and desuperheater by using flash from circulated boiler water to generate 15-lb. steam, if necessary.

The deaerating heater, floating on the 15-lb. steam line, receives water (directly, or through surge well) from mill returns, water-treating system and condenser condensate. Blow-down, with flash tank and two heat exchangers, is continuous.

Water System

A conduit 5,000-ft. long brings water by gravity from Lake Erie to water-treating plant at temperatures of 32 to 80 F. It is lifted by three 5,000-g.p.m. deep-well pumps, each driven by a 226-hp. motor. Pump discharge is split into two main parts, one going directly to the treating system, the other first to the condenser (as circulating water), then to treating. Divisicn is controlled to give 105-F process water summer and winter. Heat balance is practically perfect in winter. In summer, some excess of water must be run through the condenser, then wasted. Heated circulating water from 1,800 tons of ammonia-condensing capacity is also delivered to the water-treating system.

Primary water-treating units in order, are: settling basin, gravity filters, pump, zeolite softeners, pump, storage pond. Water leaving the storage pond goes mainly to process. That fraction going to boilers through blow-down heat-exchanger, surge well and deaerating heater may, at some later date, be given an additional treatment as feedwater.

The hot-water storage pond, holding 1,500,000 gal., is a valuable "flywheel" in heat balance, absorbing temporary unbalances in power and heat demands. Cold service water is supplied through the separate treating system shown at the bottom of the flow chart.

Following is a partial analysis of Lake Erie water for a typical day in summer:

	P.P.M.
Temporary hardness (as $CaCo_3$)	87.0
Permanent hardness	19.0
Total hardness	106.0
pH	7.9
Chlorides (as Cl)	31.0
M.O. alkalinity (as $CaCo_3$)	87.0
Phen. alkalinity	0.0

The three steam-generating units each have a maximum continuous capacity of 90,000 lb. of steam per hr., at 725 lb. and 780 F (superheater outlet). Pulverized coal is fired in a completely waterwalled furnace to insure dry-bottom operation with high-volatile, low-fusion-ash fuel. Two pulverizers and two burners per burner. Each unit has a plate-type air heater (no economizer) and a

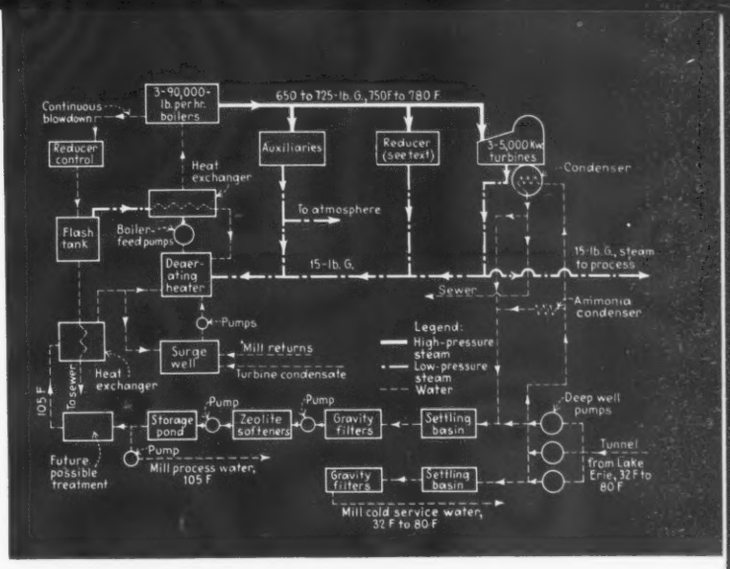
cyclone-type dust separator to insure clean air for town and avoid contamination of product.

Each boiler has one forced- and one induced-draft fan. Fans and pulverizers (also feed pumps) provide an opportunity to combine motor and turbine drives for reliability and heat-balance control. One boiler—the usual standby unit—has all motor drives on fans and pulverizers. Each of the other two boilers has dual drives on forced- and induced-draft fans and on one of its two pulverizers (the other is motor driven).

In each case, dual-drive units couple motor to driven unit and then connect the turbine to the other end of the motor shaft through a "free-wheeling" clutch. One of the two large feed pumps is steam driven, the other motor driven, providing additional flexibility.

Coal is brought by railroad cars to either storage or crusher; then from crusher to bucket elevator, to bunker, to scales, to pulverizer. Ash is handled by pneumatic conveyor to submerged pit, from which it is picked up by locomotive crane.

Three Westinghouse 5,000-kw., 3,600 r.p.m. turbines take steam at 650 lb. and 750 F, bleed to process and the deaerating feed heater at 15-lb. G and exhaust at 1.0 lb. abs. to a 2,750-sq. ft. surface condenser. Generator is a 6,250-kva., 0.80-p.f., 3-phase, 11,000-volt unit. All auxiliary motors are 440-volt. A 300-kw. gasoline engine-driven generating set (440 volts) provides an emergency power source, entirely independent of steam.



Flow diagram. Feature: Main condensers serve as heaters to maintain factory process water at 105 F

PRINCIPAL POWER PLANT EQUIPMENT

Industrial Rayon Corporation, Painesville, Ohio

Consulting Engineers.....Company Engineers
Boilers and water-walls.....Combustion Engineering Co.
Boilers, 3; heating surface each, 8,700 sq.ft.; water-walls each, 1,857 sq.ft.; max. continuous steaming cap. each, 90,000 lb. per hr.; working pressure 725 lb. G.; total steam temp., 780 F.
Superheater.....The Superheater Co.
Steam washers, 1 per boiler in drum....Combustion Engineering Co.
Air heater, 10,560 sq.ft.....Combustion Engineering Co.
Boiler and furnace settings.....Combustion Engineering Co.
Armored blocks on furnace walls.....Combustion Engineering Co.
Boiler ducts and breechings.....Combustion Engineering Co.
Stack, radial brick type supported on boiler-house steel
Alphonse Custodis
Structural-steel contractor.....The Hunkin-Conkey Constr. Co.

COMBUSTION EQUIPMENT:

Soot-blowers.....Bayer Soot Blower Co.
Pulverized-coal burners, 2 per boiler; cap. each, 6,500 lb. per hour
Combustion Engineering Co.
Coal pulverizers, 2 per boiler; bowl type: cap. each, 6,500 lb. per hr.
Combustion Engineering Co.
Pulverizer drives, 6 induction motors; 75 hp.; 1,800 r.p.m.; 440 volts
Westinghouse Elec. & Mfg. Co.
Pulverizer drives, 2 turbines used with 2 of above motors for dual drive of two units.....
Coal feeders.....Combustion Engineering Co.
Ignition torch, oil-burning.....Combustion Engineering Co.
Pulverizer-motor couplings.....Poole Flexible Coupling Co.
Pulverizer-turbine clutches, "Fast".....Bartlett Hayward Co.
Forced-draft fans, 1 per boiler; cap. each, 27,600 c.f.m.; static pressure 8.7 in.....American Blower Corp.
Forced-draft fan drives, 3 induction motors; 60 hp.; 1,800 r.p.m.; 440 volts.....Westinghouse Elec. & Mfg. Co.
Forced-draft-fan drives, 2 turbines used with 2 of above motors for dual drive of two units; 60 hp. each; 1,800 r.p.m.
Westinghouse Elec. & Mfg. Co.
Induced-draft fans, 1 per boiler; cap. each, 51,000 c.f.m.; static pressure 9.2 in., Sirrocco.....American Blower Co.
Induced-draft-fan drives, 3 induction motors; 125 hp.; 900 r.p.m.; 440 volts.....Westinghouse Elec. & Mfg. Co.
Induced-draft-fan drives, 2 turbines used with 2 of above motors for dual drive of two units; 125 hp. each; 900 r.p.m.
Westinghouse Elec. & Mfg. Co.

COAL-HANDLING EQUIPMENT:

Coal-handling apron feeder, conveyors and tripper.....Link Belt Co.
Coal-handling motors and controllers....Westinghouse Elec. & Mfg. Co.
Coal crusher, capacity, 100 tons per hr.....Link Belt Co.
Crusher driving motor, induction; 60 hp..Westinghouse Elec. & Mfg. Co.
Crusher feeder motor, 7½ hp.....Westinghouse Elec. & Mfg. Co.
Crusher motor control.....Westinghouse Elec. & Mfg. Co.
Locomotive crane.....Link Belt Co.
Coal bunkers.....The Hunkin-Conkey Constr. Co.
Coal gates.....Link Belt Co.
Coal scales.....Richardson Scale Co.

ASH-HANDLING EQUIPMENT:

Ash and soot precipitator.....Prat-Daniel Corp.

VALVES:

Safety valves.....Crosby Steam Gage & Valve Co.
Blowdown valves.....Yarnall-Waring Co.
Non-return valves.....Golden Anderson Valve Specialty Co.
Non-return valves on turbine bleed lines.....Atwood-Morrell Co.
Stop and check valves in feed lines.....Edward Valve & Mfg. Co.
High-pressure steel valves.....Chapman Valve Mfg. Co.
Medium-pressure valves.....Crane Co.
Low-pressure valves.....Crane Co.
Reducing valves.....Not yet selected
Atmospheric relief valves.....Not yet selected

PIPING, TRAPS AND STRAINERS:

Piping and insulation contractors.....Not yet selected
High-pressure traps.....Not yet selected
Low-pressure traps.....Not yet selected
Strainers.....Not yet selected

FEEDWATER SYSTEM:

Water columns, bicolor type.....Diamond Power Specialty Co.
Feedwater regulators.....Northern Equipment Co.
Boiler-feed pumps
One 540-g.p.m., 1900-ft. head, 3,550-r.p.m. motor-driven
Goulds Pumps Inc.
One 540-g.p.m., 1,900-ft. head, 3,550-r.p.m. turbine-driven
Goulds Pumps Inc.
One 270-g.p.m., 1,900-ft. head, 3,550-r.p.m. motor-driven
Goulds Pumps Inc.
Feed-pump motors
One 350-hp., 3,550-r.p.m., 440-volt....Westinghouse Elec. & Mfg. Co.
One 200-hp., 3,550-r.p.m., 440-volt....Westinghouse Elec. & Mfg. Co.
Feed-pump turbine
One 350-hp., 3,550 r.p.m.....
Surge-well pumps, 2; 540 g.p.m.; 160-ft. head, 3,550 r.p.m.
Goulds Pumps Inc.
Surge-well pump drives, 2; 28-hp. motors
Westinghouse Elec. & Mfg. Co.
Feedwater purification equipment.....Not yet selected
Deaerating heater.....Cochrane Corp.
Continuous blowdown equipment.....Cochrane Corp.

METERS AND INSTRUMENTS:

Steam flowmeters.....Taylor Instrument Companies
Feedwater flowmeters.....Taylor Instrument Companies
Draft gages.....Hays Corp
Steam pressure and temp. recorders....Taylor Instrument Companies
CO_2 recorder.....Permutit Co.

GENERATING UNITS:

Three 5,000-kw., 3,600-r.p.m., steam turbines; throttle steam conditions 650 lb. G.; total steam temp., 750 F.; automatic extraction at 15 lb. G.; exhaust pressure 1.0 lb. abs.
Westinghouse Elec. & Mfg. Co.
Turbines connect directly to 6,250-k.v.a., 0.80-p.f., 3-phase, 60-cycle 11,000-volt generators.....Westinghouse Elec. & Mfg. Co.
Generator air cooler.....Westinghouse Elec. & Mfg. Co.
Oil cooler.....Westinghouse Elec. & Mfg. Co.
Oil filter, continuous system.....F. S. Bowser & Co.

CONDENSER AND MISCELLANEOUS PUMPS:

Condenser, 2,750 sq.ft.....Westinghouse Elec. & Mfg. Co.
Deepwell lake pumps, 3; 226 hp., 5,000 g.p.m., 150-ft. head, 1,160 r.p.m.....Peerless Pump Co.
Soft water to plant pumps, 2; 103 hp., 2,200 g.p.m., 160-ft. head, 1,750 r.p.m.....Goulds Pumps Inc.
Sanitary water to plant pumps, 2; 48-hp., 1,000 g.p.m., 160 ft. head, 1750 r.p.m.....Goulds Pumps Inc.
Filtered water to softener pumps, 2; 33 hp., 2,200 g.p.m., 50-ft. head, 1,150 r.p.m.....Goulds Pumps Inc.
Backwash pumps, 2; 31 hp., 2,250 g.p.m., 45-ft. head, 1,150 r.p.m.
Goulds Pumps Inc.
Alum pump (Duriron), 2; 2 hp., 50 g.p.m., 35-ft. head, 1,750 r.p.m.
Goulds Pumps Inc.
Salt water solution pumps, 2; 8 hp., 250 g.p.m., 80-ft. head, 1,750 r.p.m.....Goulds Pumps Inc.
Plant makeup pumps, 120,000 lb. per hr.....Not yet selected
Plant condensate pumps.....Not yet selected
Pump drives, motors.....Westinghouse Elec. & Mfg. Co.

MISCELLANEOUS:

Exciters, turbine-driven.....Westinghouse Elec. & Mfg. Co.
Exciters, motor-driven.....Westinghouse Elec. & Mfg. Co.
Station switchboard.....Westinghouse Elec. & Mfg. Co.
Station transformers.....Westinghouse Elec. & Mfg. Co.
Station lightning transformers.....Westinghouse Elec. & Mfg. Co.
Oil circuit breakers.....Westinghouse Elec. & Mfg. Co.
Bus bars.....Westinghouse Elec. & Mfg. Co.
Station lighting and auxiliary conductors.Triangle Conduit & Cable Co.
Traveling crane.....Victor R. Browning Co.
Emergency power unit, 500-hp., 1,200 r.p.m., gasoline engine
Sterling Engine Co.
Generator, 300-kw., 375 k.v.a., 440 volt, 60 cycle, 3 phase
Westinghouse Elec. & Mfg. Co.

SEAVIEW

Seaview Hospital outgrows its 1922 model power plant; installs new equipment throughout. Boilers burn anthracite on chain grates

SEAVIEW Hospital of New York City, on Staten Island, was established in 1922. Since then it has been enlarged periodically, until now it is next to the largest institution of its kind operated by the city and includes a wide variety of hospital accommodations. All power, steam, heating, hot water, refrigeration and similar services are provided by a steam power plant operated as part of the hospital. In 1935, the City's Department of Hospitals, under the direction of Commissioner Dr. S. S. Goldwater, decided to enlarge this hospital again, and retained Walker & Gillette as the architects, with Tenney & Ohmes, Inc., as consulting engineers, to make plans and specifications and to superintend construction.

Former Plant

The older power plant, which is 15 years old, was not only inadequate for the enlarged institution, but badly in need of modernizing. A new plant built on the site of the old one would meet present requirements and provide for future extensions. The new plant is complete and in operation.

The old plant originally contained a 75-kw. and three 200-kw. engine-driven, 2-phase, 60-cycle, 240-volt generators; two steam-engine-driven 30-ton CO_2 refrigeration compressors; and eight hand-fired boilers equipped with forced-draft fans. In 1922, when trackless trolleys came to Staten Island, the Seaview Hospital power plant was expanded with a steam-engine-driven, 300-kw., 2,300-volt, 3-phase, 60-cycle generator to supply power for the trolleys. Steam for this unit was taken from the old boilers. In the building with the 2,300-volt generator were installed two 75-ton refrigerating compressors. Later, when trackless trolleys were replaced by buses and the hospital required more power capacity, this generator was tied into its power system through Scott-connected transformers that converted the 2,300-volt, 3-phase power into 240-volt, 2-phase. Thus, in 1935, the old power plant had a generating capacity of 975 kw.

The old boilers were arranged in two rows of five on one side and three on the other of a wide firing aisle. One old boiler was removed from the row of three to provide space for two new units. For the present, the seven old boilers will be retained for standby service. When added capacity is needed, the two old boilers in front of the new ones will be removed and two more new ones installed facing the present two new ones. A similar process will be followed on the opposite side of the old firing aisle until eight new boilers are installed, four on each side of a firing aisle at right angles to the old one.

Two new Erie inclined water-tube boilers have 6,190 sq. ft. of water-heating surface each, and are designed for 200 lb. per sq. in. working pressure without superheat. For the present they will operate at 125 lb. and later steam pressure will be increased to 150 lb. Firing is done by traveling-grate stokers, equipped with forced draft delivered to a 5-compartment wind box. They are guaranteed to burn 33 lb. of dry No. 3 buckwheat anthracite per sq. ft. per hr. and give a combined boiler and furnace efficiency of 71%, when delivering steam at 166% of normal boiler rating. The fuel as burned has 4 to 6% volatile, 64 to 70% fixed carbon, 8 to 10% moisture, 18 to 20% ash and a heating value of about 11,500 B.t.u. Under test the combined boiler and furnace efficiency was 75.5% at 160% rating.

Coal Handling

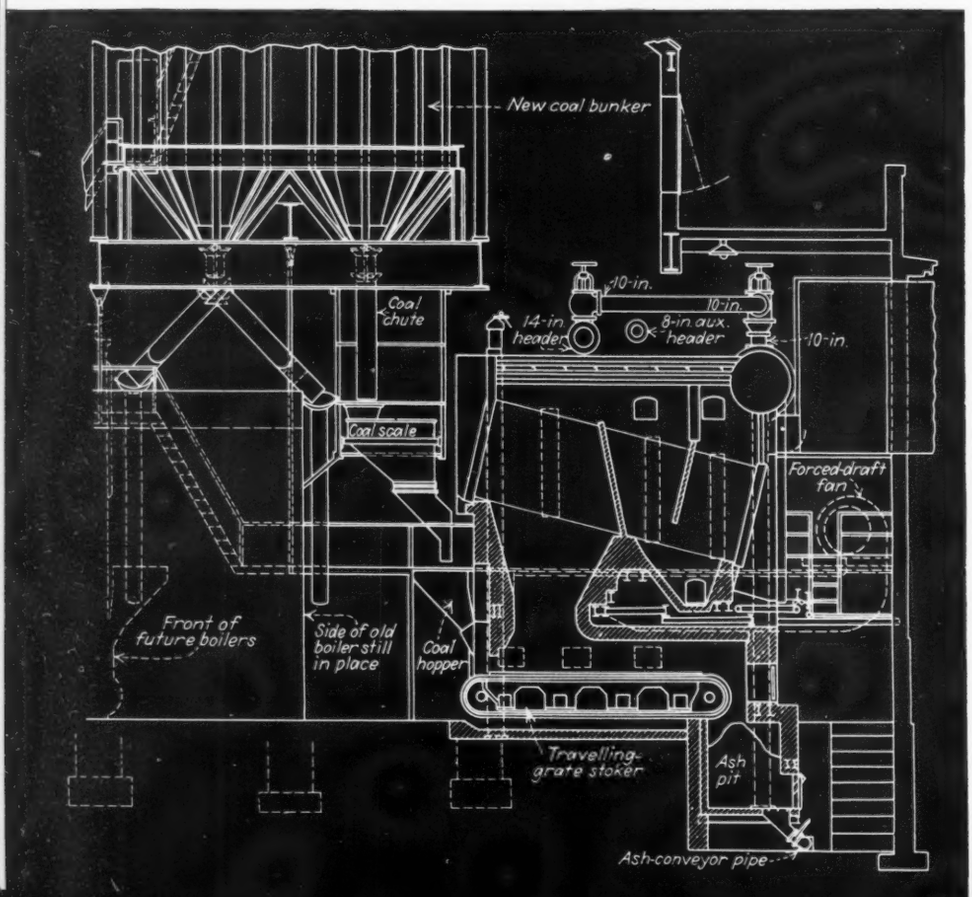
A new coal bunker above the new firing aisle has been provided for four new boilers. Coal is delivered to the old bunker by a bucket conveyor. A movable rubber-belt conveyor has been installed at right angles to the bucket conveyor and runs over the new bunker. This belt conveyor, 24 in. wide, is positioned under the bucket conveyor, which unloads on it. The belt conveyor dumps at the end, coal being distributed in the bunker by positioning the conveyor.

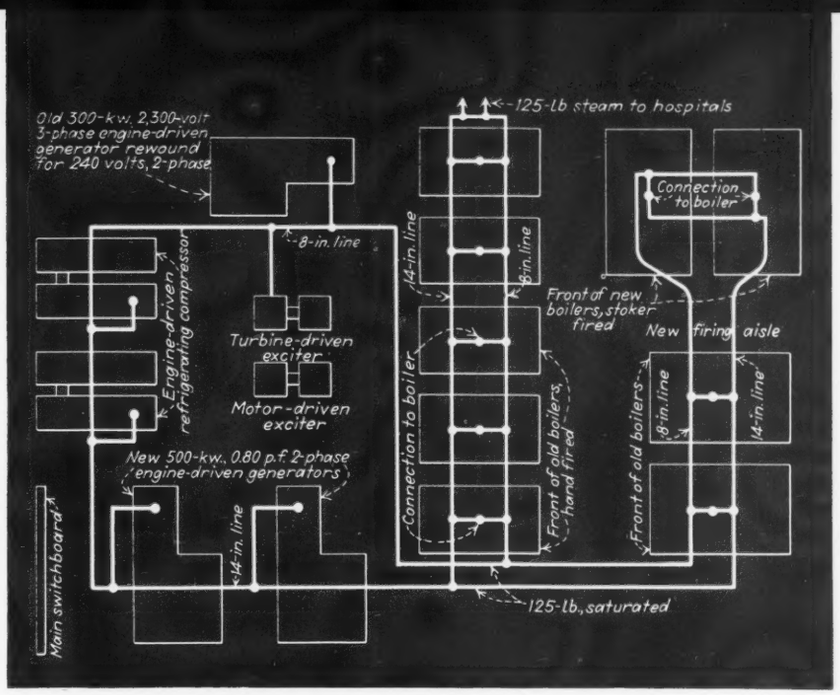
Fuel is weighed to each stoker by an automatic belt-feeder scale, which can be moved the width of the boiler to distribute the coal in the stoker hopper. A 2-hp. squirrel-cage motor drives each stoker through gearing and a variable-speed transmission that will give a stoker speed corresponding to 25 to 200% of boiler rating.

On each boiler, a constant-speed motor drives a forced-draft fan with a damper in its outlet. Position of this damper and stoker speed are adjusted automatically by combustion control to proportion fuel and air to steam demand. Furnace pressure is maintained constant by an automatic regulator on the boiler uptake damper. Forced draft in the stoker compartments is adjusted manually to maintain proper distribution of air through the fire, draft in each compartment being indicated by a 5-point draft gage.

Prime movers are two Elliott 500-kw., 150-r.p.m., horizontal-engine-driven generators. Non-releasing Corliss-valve engines are designed to operate on 150-lb. saturated steam against 5-lb. G. backpressure. Under these conditions, cutoff is guaranteed

Steam-generating units: 30,000-lb.-per-hr. max. continuous capacity at 200 lb. saturated





Flow diagram. Feature: Boilers connect to a loop header that supplies steam to power plant and hospitals

not to exceed 25% at full load. Their guaranteed steam rates at 150-lb. throttle pressure and 0 lb. G. back-pressure are 55 lb. of steam per kw.-hr. at 25% full load; 40 lb. at 50% load; 36 lb. at 75% load; 34 lb. at 100% load; and 36 lb. at 125% load. Under acceptance tests they delivered a kilowatt-hour on 46.8 lb. at 25% load and 32.5 lb. at full load.

Generators

The generators are rated 625 kva., 80% power factor, 2 phase, 60 cycles, 240 volts and are mounted directly on the engine shaft. An exceptionally heavy flywheel is provided so that with an electronic-tube-type automatic voltage regulator, when operating at 50 to 100% load, a 15% full-load change will cause no perceptible flicker in the brilliancy of a 100-watt or larger lamp connected to the generator terminals.

Two 50-kw. 125-volt exciters are provided, one motor driven and the other turbine driven. Except during starting, exciters are excited from the alternating-current generator, through a combination vacuum-tube grid-controlled rectifier and automatic voltage regulator. This equipment provides a high-speed excitation system that with properly designed generators, holds the voltage practically constant irrespective of load fluctuations. The regulator has no moving contacts, consequently acts almost instantaneously and can supply up to 800 volts across exciter field coils. A regulator is provided for each generator, and these can be operated in parallel.

Cables running between generators and switchboard are lead covered, rigidly supported on insulators in an iron-plate-covered concrete trench. The iron covers are readily removed for convenient inspection of the cable. Power is distributed outside the plant in the same type of construction where cables go underground into a duct system. On the switchboard the generator leads connect to the busbars through trip-free air-break circuit breakers that serve as generator switches and circuit breakers. To buildings near the plant, power for motors is distributed at 240 volts, 3-wire, 2-phase, and for lighting it is taken through two transformers and changed to 5-wire, 2-phase, 240 and 120 volts. For the more distant buildings, power is stepped up to 2,300 volts for transmission and stepped down again at points where current is used.

The new generators and switchboard are housed in an extension to the building in which the 2,300-volt generator and the two new refrigerating compressors are installed. This brings all power-generating equipment into one room conveniently arranged, as it would be if an entirely new plant were built. The old 2,300-volt, 3-phase generator has been rewound for 240-volt 2-phase to operate in parallel with the two new units. This gives the plant a total capacity of 1,300 kw., which will take care of load demand for several years.

PRINCIPAL EQUIPMENT IN NEW POWER PLANT

Seaview Hospital, New York, N. Y.

Architects	Walker & Gillette
Consulting Engineers	Tenney & Ohmes Inc.
Boilers	Erie City Iron Works
Boilers, 2; heating surface each, 6,190 sq.ft.; max. continuous capacity 30,000 lb. per hr.; working press., 150 lb. G; design pressure 200 lb. G; total steam temp. 365 F (sat.); furnace volume, 575 cu.ft.; max. B.t.u. liberated per hr. per cu.ft. of furnace volume, 74,000.	
Boiler and furnace settings	F. W. Kaelber, Inc.
Furnace refractories	Bigelow Liptak Co.
Boiler heat insulation	Asbestos Construction Co.
Boiler ducts and breechings	Somaron Sheet Metal Works
Stack, radial brick	Alphons Custodis Chimney Const. Co.
Steam-equipment contractor	Afgo Engineering Co.
Structural steel contractor	Belmont Iron Works
General contractor	John Milnes Construction Co.
COMBUSTION EQUIPMENT:	
Automatic combustion control	A. W. Cash Co.
Soot blowers	Vulcan Soot Blower Co.
Stokers, 2; travelling grate	Combustion Engineering Corp.
Stoker variable-speed transmission	Reeves Pulley Co.
Stoker-speed control, automatic from combustion control	A.W. Cash Co.
Forced-draft fans, 2	American Blower Corp.
Forced-draft-fan drive, 15-hp. motors	Howell Electric Motors Co.
Forcer-draft-fan motor starter	General Electric Co.
COAL- AND ASH-HANDLING EQUIPMENT:	
Coal-handling equipment, belt conveyor	Jeffrey Mfg. Co.
Coal bunker	Hahn Engineering Co.
Automatic scales, 2	Richardson Scale Co.
Ash-handling equipment	National Conveyor Co.
VALVES:	
Safety valves	Consolidated Ashcroft Hancock Co.
Blowdown valves	Homestead Valve Mfg. Co.
Non-return valves	Foster Engineering Co.
High and low-pressure valves	Fairbanks Co.
PIPING, TRAPS AND STRAINERS:	
Traps	Kieley & Muller, Inc.
Piping contractor	Afgo Engineering Co.
Pipe heat insulation	Asbestos Construction Co.
FEEDWATER SYSTEM:	
Water columns	Reliance Gauge Column Co.
Boiler-feed pump, duplex plunger, double acting	Dean Bros.
Boiler-feed-pump governor	Fisher Governor Co.
METERS:	
Boiler-load and draft differential recorder	Republic Flow Meters Co.
5-point draft gage	Republic Flow Meters Co.
Stack-temperature recorder	Republic Flow Meters Co.
Steam-pressure gages	J. E. Lonergan Co.
GENERATING UNITS:	
Two, non-releasing, 4-valve, Corliss-type, 150-r.p.m., single-cyl. steam engines with extra-heavy flywheels	Elliott Co.
Engines connect directly to 625-k.v.a., 0.80-p.f., 240-volt, 60-cycle, 2-phase generators	Elliott Co.
Exciters, two, 50 kw. each, 120 volts, one motor and one turbine driven	Elliott Co.
Muffler tank and grease extractor on engine exhaust	Downington Iron Works
Steam separators	Wright Austin Co.
Engine lubricators	Hills McCanna Co.
Oil purifiers on engines	Elliott Co.
Electrical contractor	McNutt, Watts & Tankard, Inc.
Switchboard	Royal Switchboard Co.
Circuit breakers	I.T.E. Circuit Breaker Co.
Field rheostats	Cutler-Hammer, Inc.
Indicating meters	Weston Electrical Instrument Co.
Voltage regulators	Ward Leonard Co.
Watthour meters	General Electric Co.
Recording wattmeters	Esterline-Angus Co.
Transformers	Westinghouse Elec. & Mfg. Co.

RHODE ISLAND HOSPITAL

By replacing an obsolete plant with a modern, high-temperature, high-pressure installation, state institutions at Howard, R. I., obtained higher efficiency, increased capacity and removed the dirt nuisance

AT HOWARD, R. I., are many state institutions, such as mental hospitals, infirmaries, parental schools and prisons, etc. In 1934 the State Public Welfare Department, Rhode Island, of which Edward P. Reidy is now director, started a $7,000,000 enlargement and improvement program at this center and employed Jenks & Ballou as consulting engineers to study and report on power, heating and other services for the enlarged facilities. This investigation led to construction of a new H.P. steam plant.

A steam power plant comprising three 1,500-sq. ft. stoker-fired boilers, operating at 125 lb. gage, and three 200-kw. engine-driven generators was operated by the hospital. This was found inadequate for the enlarged institution. If this plant were to be used as part of enlarged power facilities, a considerable investment would be required for improvements, as it was about 25 years old. Because of the low pressure and temperature at which the plant operated, a large excess of exhaust steam discharged to atmosphere in the off-heating season. Five ways of supplying power, heat, hot water and other services were considered by the consulting engineers:

A. Recondition the old plant and add a new stoker-fired, 5,000-sq. ft. boiler and purchase power needed above that supplied by the plant.

B. Recondition the power plant, add two new 5,000-sq. ft. stoker-fired boilers and purchase power.

C. Recondition old plant, install two new 5,000-sq. ft. boilers and a 500-kw. uniflow-engine-driven generator.

D. Recondition the old plant, install one new boiler having a steaming capacity of 65,000 lb. per hr. and a 500-kw. uniflow-engine-driven generator.

E. Scrap the old steam-engine plant, install a new high-pressure, high-temperature plant, with oil-fired boilers serving turbine-generators, of sufficient capacity to supply the power load; and recondition the old boilers for oil firing to supply the steam demand above that available from power generation during the heating season.

Plan Selected

Choice E proved to be most economical, all things considered. It provided for a large increase in operating efficiency, because of high pressure and temperature; allowed enlarging the power and steam facilities with the least interference with the old plant during construction; provided a new power-generating plant, designed for the highest economy, all things considered, because the old plant was not a limiting factor; provided ample power and steam capacity at all seasons (lacking in some of the other proposals); and removed the dust and dirt nuisance from coal and ash handling.

For the new plant, a steam pressure of 400 lb. and a temperature of 600 F were selected as being most economical. These steam conditions would permit generating power in the off-heating season without exhaust going to waste. Large quantities of medium pressure and low-pressure steam are required even in summer months for laundry service, water heating, cooking, sterilizing and other purposes. Because of the long distances that part of this steam is transmitted and the high temperatures required for some services, a considerable quantity was distributed at 125 lb., the old boiler pressure. To meet these requirements in the new plant, turbines were selected to bleed at 100 lb. into the present 125-lb. distribution system and exhaust at 5 lb. into the low-pressure mains. To provide additional steam required during the heating season, when load may reach 125,000 lb. per hr., one or more old boilers will be operated at 100-lb. pressure on the 100-lb. distribution system, low-pressure steam being obtained through reducing valves.

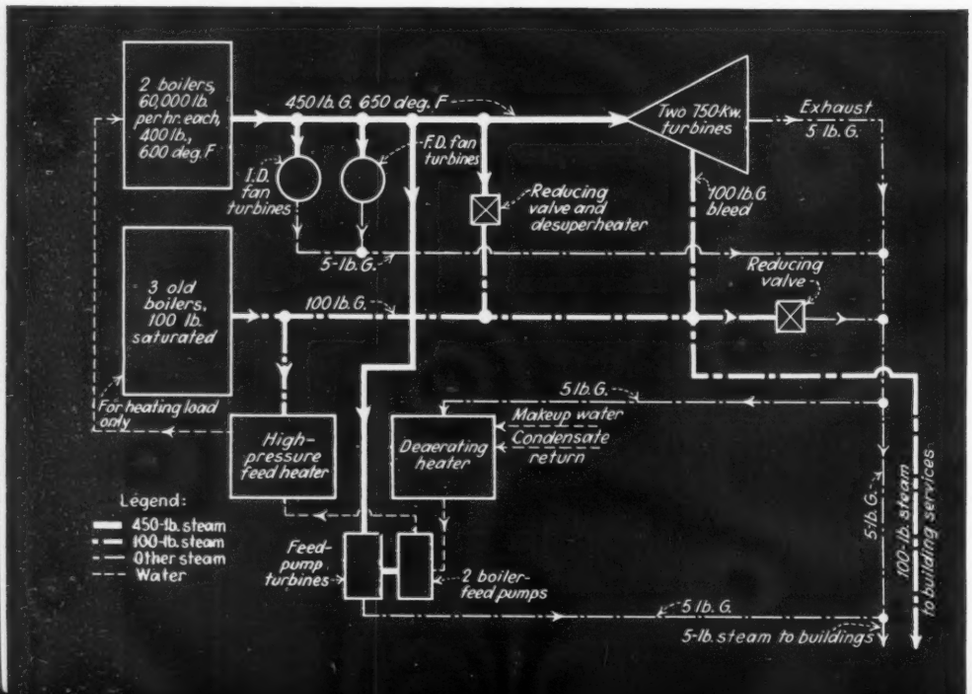
Central-station and industrial-plant engineers for many years have been taking advantage of the economies obtained by using high-pressure and high-temperature steam. Such plants are now practically as reliable and simple to operate as those using lower pressures, but for the most part institution power plants have continued to be designed for pressures of 150 lb. or less. The use of high-pressure, high-temperature steam at Howard is a step for higher economy in institutional power-plant design for which both consulting engineers and hospital executives are to be commended.

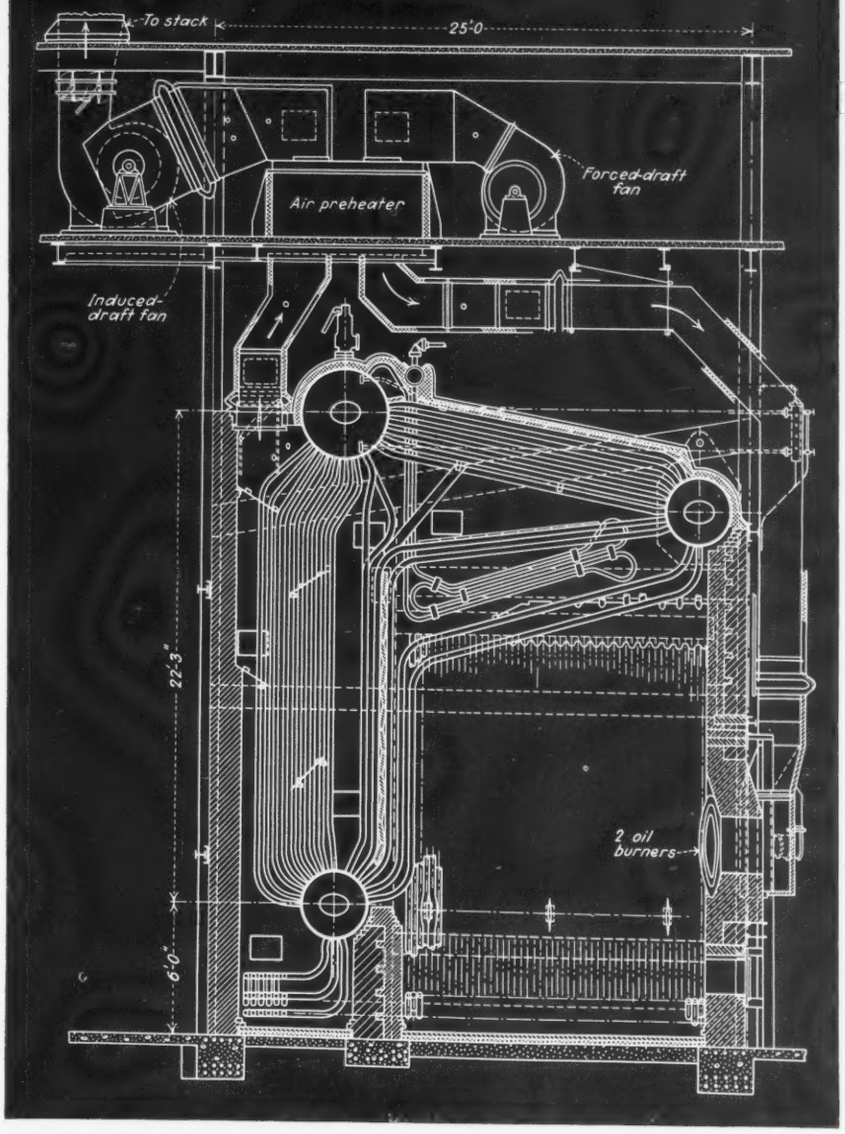
Boiler Units

Steam is supplied by two Riley boilers, each having a continuous capacity of 60,000 lb. per hr., at a working pressure of 450 lb. per sq. in. and superheated to give a total temperature of 600 F. Air heaters to give a combustion air temperature of 400 F are installed. The air heaters, forced- and induced-draft fans, are on a floor just above the boiler. This gives a very compact arrangement of fans and air heaters with short gas and air ducts. Induced-draft fans discharge into a self-supporting steel stack 100 ft. high above the boiler-room floor.

Firing of each boiler is by two steam-atomizing oil burners set on a horizontal line in the furnace front, with their center lines on an angle that meets approximately in the furnace center. As shown in the boiler cross-section, the rear of the furnace is part of the boiler. In addition, furnace side walls and floor are water-cooled with tubes over which a refractory compound is sprayed. Straight refractory furnace-front walls insure good ignition of oil over a wide range of load.

Flow Diagram. Feature: Two 750-kw. turbo-generators bleed at 100 lb. into the old 125-lb. main and exhaust at 5 lb. into the old low-pressure distribution system





Steam Generators: Two, each of 60,000 lb. per hr., max. steaming capacity at 450 lb. and 600 F

Because of the large demands for low-pressure steam, and the flexible speed control obtained with turbines, forced- and induced-draft fans and boiler feed pumps are driven by turbines using high-pressure steam and exhausting at 5 lb. backpressure. Firing is under control of an automatic combustion-control system, which adjusts fuel flow and forced- and induced-draft fan speed according to steam demands, as indicated by a master regulator. Furnace pressure is maintained constant by a regulator adjusting a damper in the forced-draft duct. The steam-flow, air-flow meter adjusts induced-draft fan speed to maintain correct steam-flow air-flow relation for the most economical combustion. Meters are provided on fuel, water, steam and combustion gas, so that boilers can be operated under practical test conditions at all times.

Power is generated by two 750-kw., 3,600-r.p.m. G.E. turbines designed for 375 lb. and 150-F superheat throttle conditions, to bleed up to 30,000 lb. of steam per hr. each, at 100 lb. gage and exhaust at 5-lb. backpressure. When operating straight non-condensing, they have a guaranteed water rate of 23.34 lb. at full load and 24.79 at 75% load. The generators are rated 937 kva., 0.80 p.f., 60 cycles, 2,300 volts, at which voltage power is distributed to the different buildings and stepped down through transformers. An automatic Telechron clock system maintains the frequency constant so that it can be used for timing purposes.

PRINCIPAL EQUIPMENT IN POWER PLANT
Rhode Island State Hospital

Consulting Engineers.....Jenks & Ballou
Building.....E. Turgeon
Boilers and waterwalls.....Riley Stoker Corp.
Boilers, 2; heating surface, each, 6,140 sq.ft.; waterwalls 1,920 sq. ft.; maximum continuous steaming capacity, 60,000 lb. per hr.; working pressure 400 lb. G; total steam temp. 600 F; furnace volume, 2,760 cu. ft.; max. B.t.u. liberated per cu.ft. per hr. 25,700,
Superheaters.....Riley Stoker Corp.
Steam scrubbers.....Riley Stoker Corp.
Air heaters, 5,000 sq. ft., Ljungstrom.....Air Preheater Corp.
Gearmotor drive on air heater.....Philadelphia Gear Works
Boiler-heat insulation.....Eagle-Picher Lead Co.
Boiler baffles.....Atlas Lumnite Cement Co.
Firebrick.....J. H. France Refractories Co.
Boiler ducts and breechings.....Riley Stoker Corp.
Stack, steel.....International Engineering Co.
Structural steel.....Providence Steel & Iron Co.

COMBUSTION EQUIPMENT:
Automatic combustion control.....Bailey Meter Co.
Soot blowers.....Vulcan Soot Blower Corp.
Oil burners, 2 per boiler, steam-atomizing.....Tyrrell, Files Eng. Co.
Oil heaters.....General Fittings Co.
Oil pumps.....Worthington Pump & Mach. Co.
Oil-pressure governor.....Bailey Meter Co.
Oil-storage tank, concrete, 2-compartment, 150,000-gal.....T. I. Ellis
Forced-draft fans, 1 per boiler, cap. each, 17,000 c.f.m.; static pressure 3.6 in.....B. F. Sturtevant Co.
Forced-draft-fan drive, 24-hp. turbine.....Morse Steam Turbine Corp.
Induced-draft fans, 1 per boiler, cap. 26,000 c.f.m.; static pressure 2.6 in.....B. F. Sturtevant Co.
Induced-draft-fan drive, 32-hp. geared turbine
Moore Steam Turbine Corp.

VALVES:
Cast-steel fittings.....Reading Steel Casting Co.
Safety valves on boilers.....Consolidated Ashcroft Hancock Co.
Safety valves on 100-lb. line.....Lonergan Co.
Blow-down valves.....Yarnall-Waring Co.
Multiport, backpressure valves on turbines.....Cochrane Corp.
Non-return valves.....Edwards Valve & Mfg. Co.
Extraction non-return valves.....Atwood & Morrill Co.
Stop and check valves on feed lines
Pratt & Cady Co. & Con. Ashcroft Hancock Co.
High-pressure valves....Pratt & Cady Co., Henry Vogt Machine Co., and Edward Valve & Mfg. Co.
Gate, globe & check valves.....Pratt & Cady Co.
Exhaust heads.....Swartwout Co.
Reducing valves.....Mason-Neilan Regulator Co.
Water relief valves.....Foster Engineering Co.
Atmospheric relief valves.....Cochrane Corp.

PIPING, TRAPS AND STRAINERS:
Piping contractor.....Hartwell Co., Inc.
Wrought-iron pipe.....A. M. Byers Co.
Steel pipe.....National Tube Co.
Pipe-heat insulation.....Philip Carey Co.
Expansion joints.....E. B. Badger & Sons Co.
High-pressure traps.....Wright-Austin Co.
Low-pressure traps.....Wright-Austin Co.
Thermostatic traps.....Warner Webster & Co.
Lifting trap.....Crane Co.
Strainers.....Wright-Austin Co.

FEEDWATER SYSTEM:
Water columns.....Reliance Gauge Column Co.
Feedwater regulators.....Stets Co.
Boiler-feed pumps, 3; cap. 150 g.p.m. each; head, 1,100 ft.....Warren Steam Pump Co.
Boiler-feed-pump governors.....Fisher Governor Co.
Feed-pump drives, 70-hp. turbines.....Terry Steam Turbine Co.
Feedwater treatment pump.....Worthington Pump & Mach. Co.
Condensate pumps, 2; cap. 250 g.p.m.....Warren Steam Pump Co.
Feedwater deaerating heater.....Cochrane Corp.
Closed feedwater heater.....Whitlock Coil Pipe Co.

METERS:
Boilermeter and control board.....Bailey Meter Co.
Boiler meters.....Bailey Meter Co.
Steam flowmeters.....Bailey Meter Co.
Steam-pressure and temperature recorder.....Bailey Meter Co.
Steam-pressure gages, indicating...Consolidated Ashcroft Hancock Co.
Water-pressure gages, indicating..Consolidated Ashcroft Hancock Co.
Venturi meter on feedwater.....Builders Iron Foundry
Thermometers, recording.....Bailey Meter Co.
Oil-flow meters.....National Meter Co.
Oil thermometers.....Taylor Instrument Co.
Oil-pressure gages.....Marsh Gage Co.
Feedwater sampler.....Cochrane Corp.
Draft gages, 4-point.....Bailey Meter Co.
Turbine-speed indicators.....General Electric Co.

GENERATING UNITS:
Two, 750-kw., 3,600-r.p.m. turbines; steam conditions, 375 lb. G., 600 F; automatic extraction at 100 lb.; exhaust pressure 5 lb. G.....General Electric Co.
Turbines connect directly to 937-kva., 0.80-p.f., 3-phase, 60-cycle generators with direct-connected exciters.....General Electric Co.
Turbine-oil cooler.....Andale Co.
Reducing valve and desuperheater station and control.Swartwout Co.
Station switchboard.....Westinghouse Elec. & Mfg. Co.
Frequency control.....Warren Telechron Co.
Oil circuit breakers.....Westinghouse Elec. & Mfg. Co.
Air compressor.....Worthington Pump & Mach. Co.

HOW ABOUT A

POWER SHORTAGE?

The "ifs" of the case leave plenty of room for argument, but the possibility cannot be laughed off. It's too close for comfort, unless manufacturers can deliver turbines and steam-generating capacity much faster than they did from 1926 to 1929. Can they? That's one of the major "ifs"

THE possibility of a "power shortage" in 1938 or '39 has reached the stage of newspaper discussion. This means that the issue is befogged not only by its natural technical difficulties, but also by the "slanting" of statements to influence public opinion for or against current proposals for government generation of hydroelectric power. As usual, public opinion is barking up the wrong tree; the building of these hydro plants, located mostly far away from populous industrial centers, could accomplish little to alleviate a power shortage.

In an attempt to get to the brass tacks of the situation, *Power* has analyzed some dependable statistics. This page gives the main conclusions. Further details will appear in future numbers.

The study involves three things: First, simple arithmetic applied to the capacity and output statistics of the Federal Power Commission, 1920 to 1936 inclusive; second, the clear statement of certain assumptions upon which the future estimates are based; third, the resulting conclusions. This is fair enough; if we don't agree as to the conclusions, we can at least define the field for debate.

The data to be discussed have been tabulated by *Power*, but cannot be presented here for lack of space. These tabulations give, year by year, from 1920 to '36, the total kilowatt capacity of all "public-supply" plants and their total yearly output in kilowatt-hours. "Public-supply" plants include central stations owned by private companies and agencies of municipal, state and federal governments; electric railways and railroads; manufacturing companies (power for other than their own use). The privately owned central stations today represent about 87% of the reported "public-supply" capacity and about 89% of the reported output. They are, therefore, the dominant element. All types of generation (hydro, steam and internal combustion engines) are included.

For the period 1920-29, inclusive, "public-supply" capacity increased from 14.4 to 31.6 million kw., an average yearly increase of 9.2%. Yearly output increased from 43.4 to 97.4 billion kw.-hr., an average yearly increase of 9.6%.

Let's pass over the disorganized period, 1930-35, start with the known facts for 1936, then work on into the unknown future. To do this, we shall make two assumptions: We shall assume that energy output for the next few years will increase 9.6% per year, as it did from 1920 to '29. This means an average increase of 13.3 billion kw.-hr. per year. To handle this and climb back to the pre-depression average of 1 kw. per 3,000 kw.-hr. by 1941 requires 4.6 million new kw.-hr. each year—230% of the 1926-29 yearly growth.

50% Faster Than in 1926-29

But the 3,000 kw.-hr. is probably *too* safe. Right now we're getting by with a national average of nearly 3,500 kw.-hr. Take that figure as the safe limit, and generating capacity must be installed at 150% of the 1926-29 rate to keep up.

The boiler situation would be eased a bit by the better steam rates of the new turbines. Knock off 10% for this, and you have a conservative estimate of required boiler installations (steaming capacity) 35% above the 1926-29 average. That's about the safest minimum after making all reasonable concessions.

How about hydro? At the end of 1936, steam represented about 70% of capacity and 64% of annual output. Diesel is unlikely to become important in this field. It is also fairly safe to predict that hydro will not gain on steam during the 1937-41 period (or thereafter).

Don't Forget the Industrials!

Finally, there is the great industrial field which, in the aggregate, has installed and buys yearly several times as much boiler capacity as the public-supply plants (but less turbine capacity). This field draws upon the same equipment-manufacturing facilities to some extent, but not entirely. Kilowatt and kilowatt-hour statistics here are meaningless, the dominant factors being the growing demand for process and heating steam, and the rate of replacement of existing equipment, most of it obsolete.

Industrial purchases are probably the most important unknown factor. We shall play safe by saying merely that the industrial demand for new power equipment, in the years just ahead, must substantially exceed that of the 1926-29 period. If this is correct, and if our estimates of minimum "public-supply" needs are within gunshot of the facts, the yearly demand for new boilers, turbines, etc., for all applications during 1937-41 will far exceed the yearly installations of the 1926-29 period.

Are manufacturers equipped to handle this business? We do not yet know; they are now studying the situation. We do know that right now their shops are jammed with orders and that much additional business would strain production facilities in many quarters.

Pending further studies, this much can be said: The case of those who insist that there is no danger of a power shortage a year or two hence lacks convincing proof. Until it is proved, it will be the part of caution for individual utilities and industrial units to place orders for capacity to be installed well in advance of immediate needs, if that is possible.

UTILITY TRENDS

Condensing units will exceed tops in volume of business . . . Most tops tailored to suit old buildings . . . Welded joints for high pressure and temperature . . . Oil-fire hazard considered corrected

THE DECADE that ended in 1930 is principally remembered for standardization of the 400 to 600-lb., 750-F plant with relatively large units, good economy (even as viewed from present standards), and a high degree of reliability. This plant type was a result of a large number of successive approximations. The same period also marks development of the 1,200-lb. reheat cycle, a necessary step toward the modern 900-F plants, and the mercury-vapor unit which represents the best so far accomplished in heat economy.

Seven lean years later, orders are once again piling up in manufacturers' shops; engineering is begun on a second project before the first can be placed in operation; new materials and new knowledge are creating new kinds of plants. Developments are rapid. It is important that significant things relating to power plants be selected, described, charted and criticized. This number of *Power* tabulates significant details of more than 100 new central-station installations and concisely describes eight of them selected as typical.

To reinforce this matter-of-fact information, we asked a number of utility engineers, responsible for equipment selection, for their opinions on questions relating to near-future trends. A few of their thoughts, tooled into a running pattern by *Power* editors, are summarized.

A year ago, orders for turbines in the 1,200-lb. class were predominantly for backpressure machines (topping units); for the past few months, however, the situation is reversed, condensing units furnishing the greater volume of business. In the opinion of central-station engineers, this does not signify that superposition is a fad and that a change of style is imminent, but rather that there are a limited number of plants in which topping units are justified. Furthermore, the first topping unit on a given system not only has first choice as to base load, but, of course, has been selected as the most desirable of the alternates available.

Superposed units will continue to be installed as long as the results of thorough engineering study indicate that the topping unit can fit the need of the particular purchaser better than some other type of unit. From time to time there will be further opportunity for economical development of superposed installations, particularly on the very large systems having several old plants, but the bulk of future capacity will be represented by condensing units.

The present level of boiler availability warrants single-boiler-per-turbine unit installation, depending on the relative size of the power block the unit represents in the system reserve. However, in many cases, increased flexibility of operation and somewhat increased availability from "two-boiler" installations, and from interconnection between units, have been considered sufficient to justify the relatively small difference in cost. In spite of the excellent availability records of some newer boiler plants, it is going to be some time yet before operators will be able to forget long and sometimes painful experience with periodic boiler outage, a factor which will influence many decisions in favor of interconnection or two-boiler layouts.

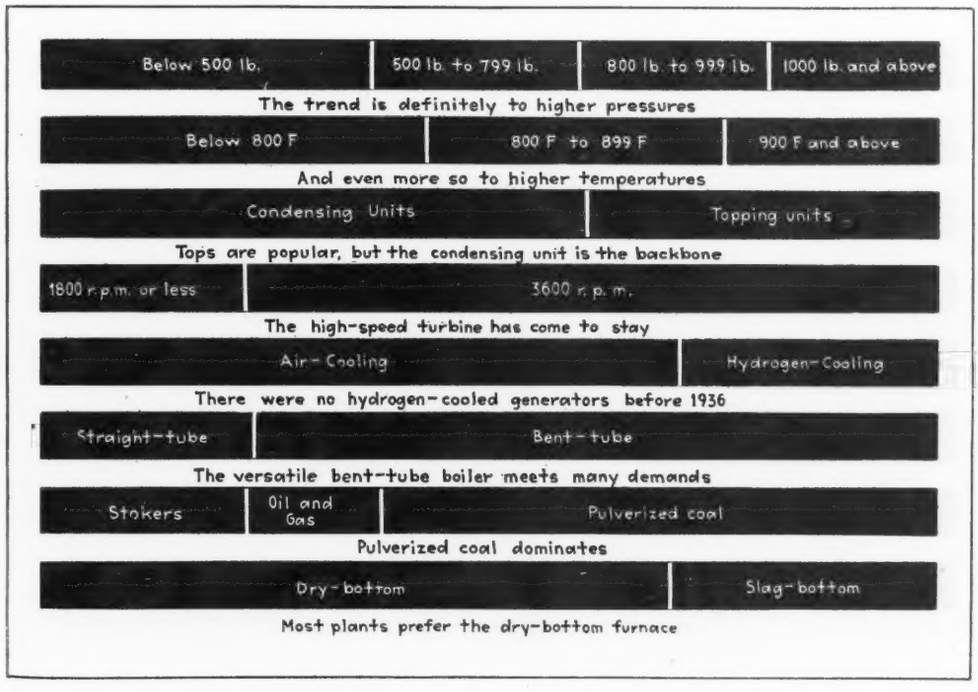
Welded Piping

Under extreme conditions of 1,200-lb., 900-F, dimensions of flanges and bolts become excessive and it is difficult to insure a tight joint. Practically all piping for this service is being welded, although it is recognized that the cost is generally higher if X-ray inspection and stress relieving are required. With one or two more years of experience in field welding, the expensive and time-consuming testing now insisted upon by some engineers may be done away with and welding costs reduced to a point at which they become equal to, or less than, those of flanged joints.

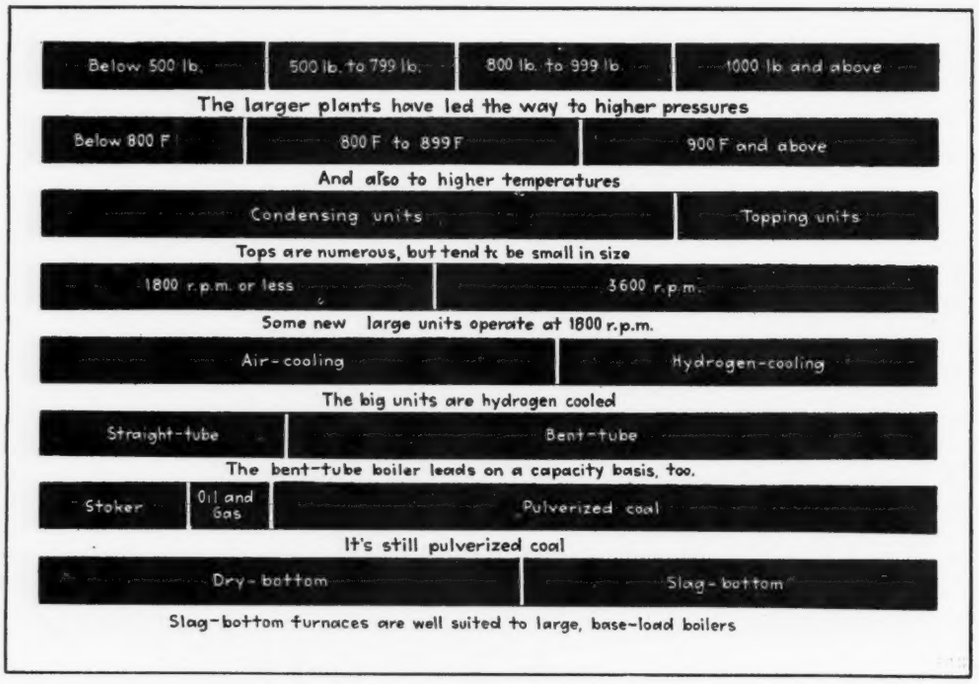
There is no unanimity of opinion concerning the

CALLING THE ROLL BY PLANTS

Major characteristics of new central-station installations are presented in this chart, based on data of the central-station table, Section II of this number. Each bar segment represents the number of installations of the type described



need for field X-ray examination; some do not require it at all, others consider the expense well justified. Perhaps the answer lies in the development of quicker and cheaper X-ray methods, use of the archronograph, or perhaps experience will show that proper qualification of welders is sufficient. Certainly a survey of welding costs, inspection costs and results achieved is of major importance and should be undertaken by a responsible agency.


Below 500 lb.
500 lb. to 799 lb.
800 lb. to 999 lb.
1000 lb and above
The larger plants have led the way to higher pressures
Below 800 F
800 F to 899 F
900 F and above
And also to higher temperatures
Condensing units
Topping units
Tops are numerous, but tend to be small in size
1800 r.p.m. or less
3600 r.p.m.
Some new large units operate at 1800 r.p.m.
Air-cooling
Hydrogen-cooling
The big units are hydrogen cooled
Straight-tube
Bent-tube
The bent-tube boiler leads on a capacity basis, too.
Stoker
Oil and Gas
Pulverized coal
It's still pulverized coal
Dry-bottom
Slag-bottom
Slag-bottom furnaces are well suited to large, base-load boilers

CALLING THE ROLL BY KILOWATTS

Again the major characteristics of new central-station installations are presented, but each bar segment of this chart represents the number of kilowatts of each type installed

Many of the new boilers have been tailored to fit the contour of existing bunkers, columns and building steel. An impression is given that every boiler is different from every other boiler, not in fact the case. Boiler development of the last few years has proceeded along the lines of orderly application of known factors, differently disposed to suit layout requirements. Improvements have been made, but they are not radically different and untried experiments, they are basically sound modifications of tried and proved elements.

Pulverized-fuel installations far outnumber new stoker-fired units. Slag-tap bottoms are preferred for large and generally speaking base-load units. The use of a combination of economizer and air preheater is universal. Many plants in urban districts have precipitators.

Practically all new central-station auxiliaries are motor driven, boiler-feed pumps being an exception where heat balance requires steam exhaust. In some cases, boiler-feed-pump turbines are provided with a bleed point.

Troubles

There has not yet been sufficient operating experience at 1,200 lb., 900 F to allow discussion of starting troubles and normal operating limitations of new plants. Omaha station has already set up an operating record of 70% boiler availability for the six months since first firing the unit. The first West End boiler has operated every week day for four months carrying its share of the boiler load. The next few months will see several more plants in operation and afford a statistical record.

Oil-Fire Hazard

The correction of turbine oil-fire hazard is probably one of the best examples of unified action in central-station practice. Designers, operators and insurance companies were all seriously alarmed by the frequency of these fires a few years ago. When the hazard of oil near hot steam was fully realized, recommendations for correcting poor design and construction were promptly put into effect. Expenditures for the recommended changes are now universally viewed as amply justified by the measure of insurance afforded against fire. Likewise the preventive measures incorporated in oil systems of new equipment, usually accomplished at little if any real extra cost, have been accepted as standard construction. While vigilance should not be relaxed, and oil fires are still possible, the measure of risk has been reduced to a reasonable minimum.

New Units in Old Buildings

Installation of new equipment in existing buildings is inherent in the superposition idea; there remains a question of the economics of condensing-unit installations in space made available by removal of obsolete equipment. Where land values are high and building costs expensive, as in metropolitan areas, maximum utilization of building investment is to be expected. Lessons already learned in the cost of building modifications to suit topping units will afford better data for economic studies than were available for super-position studies.

Within a few years, perhaps sooner, many systems will have to face a choice between existing plant extension, involving retirement of relatively large amounts of fixed capital, and new station construction requiring a large initial outlay of new money for the first unit. The power supply economics involved will require a greater amount of study of transmission and distribution conditions than heretofore, simply because the systems are larger and more complex. Large savings in the cost of power generation resulting from improved cycle or large units will no longer enter the studies as an influential factor. Engineers will search for projects that represent least cost of power supply to the ultimate consumer. Then too, most of the larger municipalities are concerning themselves with smoke, cinders and fly-ash in a serious way, a factor which works against the construction of new large urban stations.

System planning will take a long time and require more technical consideration of new problems in selection of location for new capacity. Well rewarded will be those engineering staffs which early appreciate the complex problem, and are prepared, in the face of rapidly increasing loads, to present well-considered and mature plans in time to avoid a capacity shortage.

FISK

1,200-lb., 900-F top kills four birds with one stone — (1) dodges circulating-water limitations, (2) salvages much of the old equipment in a historic station, (3) adds 30,000 kw. to capacity, (4) cuts heat rate from 24,000 to 12,150 B.t.u. per kw.-hr.

FISK STATION of the Commonwealth Edison Company, located close to the Chicago "Loop" district, is a landmark in central-station history. First operated in 1903, Fisk was the earliest steam plant designed solely for steam turbines.

No new generating capacity has been added at Fisk since 1920 when a 35,000-kw. compound turbine-generator filled the available turbine-room space. In 1936, the generating capacity consisted of two horizontal-compound 25-cycle units, 25,000 and 35,000 kw., and 10 vertical, 25-cycle, 12,000-kw. machines. There were two 60-cycle horizontal units aggregating 50,000 kw. Total of generator ratings was 230,000 kw.

The boiler plant, prior to the present construction, consisted of several of the original 5,000-sq. ft. natural-draft boilers, little used now, and sixteen 220-lb. pressure, 550-F boilers, chain-grate-stoker fired, installed during the period from 1913 to 1918. These latter boilers are now in regular daily operation.

Present Program

Removal of two rows of 5,000-sq.ft. natural-draft boilers has provided space within the existing boiler-house structure for the new turbine as well as the two new steam-generating units. The only change to the building structure is a slight increase in height of boiler house and openings cut in the dividing wall between boiler house and turbine room. It has not been necessary to remove any of the existing turbines. Assembly of the new turbine is nearly complete and boiler construction is well advanced; initial operation is expected within a few months.

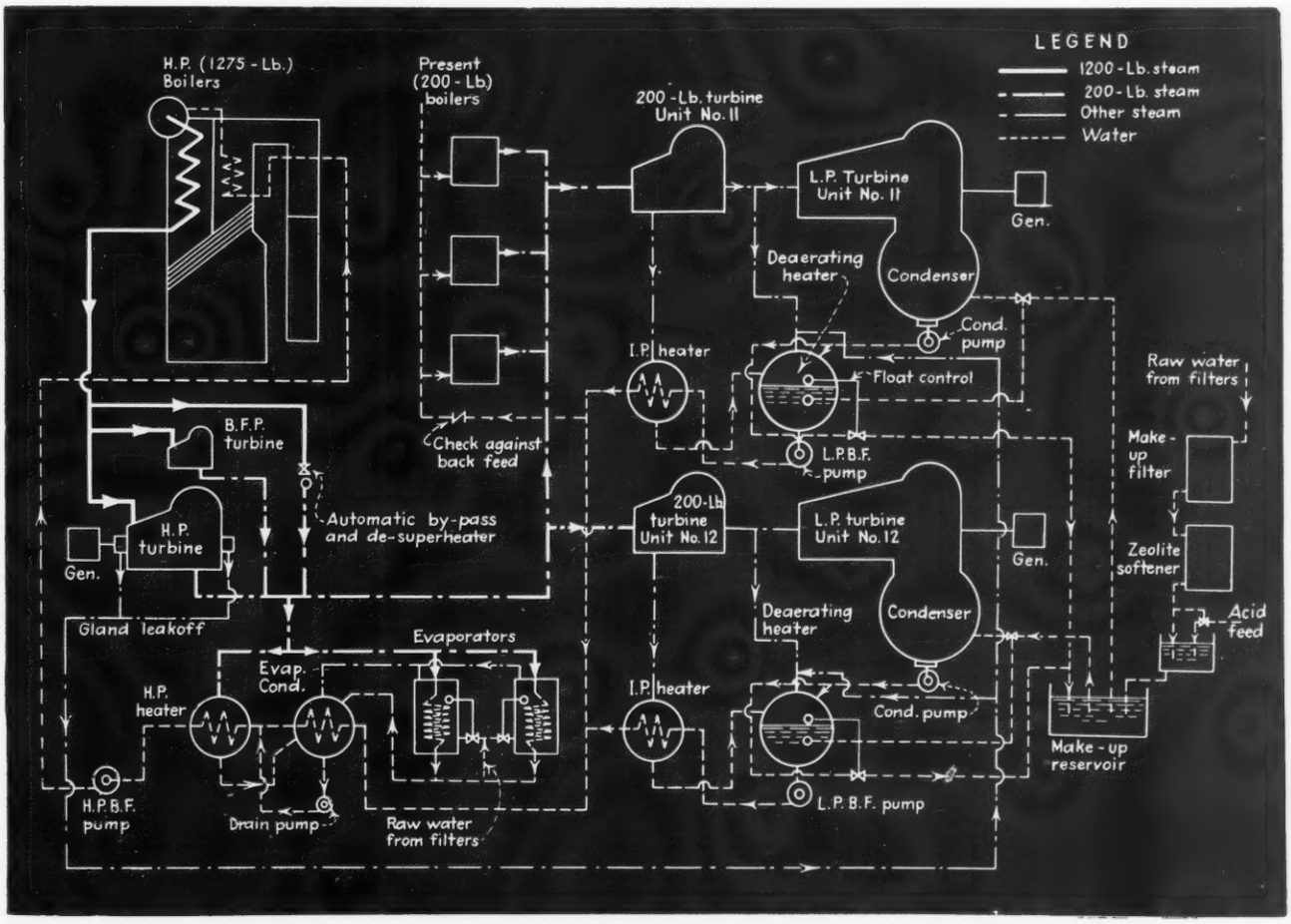
Recent additions to generating capacity in the Chicago district have been in the outlying plants because of the limited circulating water from the Chicago River. Development of the superposed unit operating on the simple 1200-lb., 900-F cycle, without reheat, affords a practical means of increasing efficiency of 25-cycle generation at Fisk as well as adding capacity at a convenient point. Circulating-water requirements have not been increased.

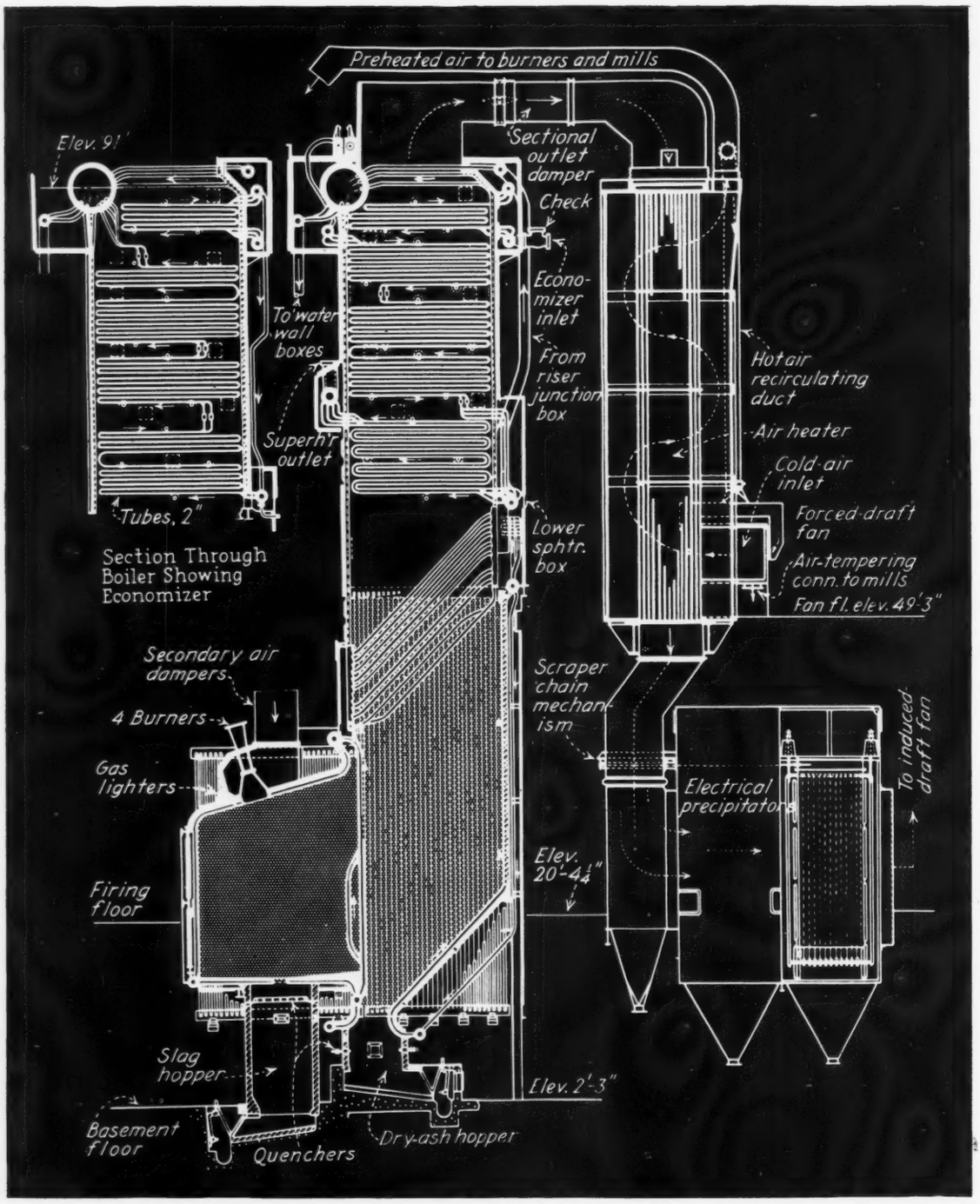
Since 1920, practically all load growth of the 25-cycle system has been supplied from the 60-cycle system by the installation of frequency changers. A changeover program in the d. c. district has kept the net 25-cycle load increase small enough to make this arrangement possible. With the new unit in operation, Fisk will carry the bulk of the 25-cycle load and at times feed into the 60-cycle system through the frequency changers.

Heat Rate

The new turbine will normally operate as a compound unit of 90,000 kw., composed of the 30,000-kw. and two horizontal low-pressure machines, aggregating 60,000 kw. The improved high-pressure cycle and the modern boiler plant will combine to reduce the heat rate from about 24,000 B.t.u. per net kw.-hr. to 12,150 for

Flow diagram. Feature: 1,200-lb. steam drives boiler-feed pump turbine exhausting to 200-lb. header





Steam-generating unit: 412,500 lb. per hr. max. capacity at 1,200 lb. and 910 F.

that part of the load carried on the new combination.

Steam-Generating Unit

Two B. & W. steam-generating units are being installed to provide maximum availablility for base-load operation over extended periods; increased flexibility of operation also results from having two units instead of a single larger one. Each has a normal output of 375,000 lb. per hr. of 1,275-lb., 910-F steam, but can produce a maximum of 412,500 when needed. Of the 99,710 sq.ft. of total heat-absorbing surface (including air preheater), only 6,640 sq.ft., or 7%, is in the sectional header steam-generating portion. The percentages of heat absorbed in the various sections are: furnace, 42; sectional header, 12; superheater, 25; economizer, 13.5; air heater, 7.5. The top of the boiler drum stands 76 ft. above furnace slag bottom.

Furnace

The furnace is divided into primary and secondary combustion space by a screen of water-cooled tubes. Studded tube waterwalls in the primary furnace accumulate an insulating layer of slag and give high furnace temperatures, conducive to good combustion as well as aiding slag flow at reduced ratings. A wide range of coals can be burned in this type furnace, which is arranged for continuous tapping of slag. The secondary furnace, of ample proportions, is of partial-stud and bare-block construction to reduce gas temperature enough to avoid slagging the sectional header tubes.

Boiler tubes are arranged in vertical lanes and inclined at an angle of 45 deg. The tubes of the lower sections of superheater and economizer are spaced on wide centers to lessen the possibility of ash accumulation. The economizer is located alongside

the superheater below the boiler-drum level and within the weld-sealed casing of the unit. Gas passes up through the superheater and economizer. Superheat control is accomplished by shifting the proportion of gas flow from one side to the other by dampers in the outlet ducts.

Two Foster Wheeler ball-type pulverizers for each boiler, feed four burners firing downward. Each boiler is served by two Sturtevant draft fans, one forced-draft, one induced-draft. The forced-draft fan is motor driven at constant speed, controlled by vanes. The induced-draft fan is equipped with two motors, one at 720 r.p.m. for normal loads, a separate motor at 900 r.p.m. is used only for high loads. Induced draft is damper controlled.

Coal and Ash Handling

Existing facilities for coal handling have been utilized as far as practical. A new 600-ton bunker has been provided and a belt conveyor (Link-Belt) installed to serve the new bunker. From the bunker, coal feeds downward directly to the Richardson individual weigh scales and mills.

Slag is continuously tapped at two floor openings, quenched and sluiced (Allen-Sherman-Hoff system). Dry ash from the secondary furnace is also sluiced in a separate trench. A conveyor (United Conveyor system) removes flyash from the duct below the air heater and from the electrostatic precipitator hoppers. The Cottrell precipitator, necessary because of the urban location of the plant, is located before the induced-draft fan to reduce erosion of fan wheels.

A new stack of all-welded construction rises 300 ft. above street level. Brick-lined, 13 ft. in diameter, it is the tallest welded self-supporting stack yet constructed. A "tee" joint, developed especially for this stack, is used for horizontal seams.

Turbine

Allis-Chalmers topping turbine is rated 30,000 kw. at 1500 r.p.m. It has a single impulse wheel and 28 reaction stages. Casing joint is bolted with new design of wedge-shaped pieces so that studs are out of high-temperature zone.

Generator is 25 cycle, 95% power factor and air cooled. If desired later, machine can be speeded up to 1800 r.p.m. to drive a 60-cycle generator. Steam is exhausted at a backpressure of 220 lb., 550 F.

Rehabilitation of Low-Pressure Turbines

35,000-kw. turbine No. 12 was rebladed in 1935 and brass sealing strips added to restore original clearances. At the same time contract-type deaerating heaters were added to both units 11 and 12, steam being supplied from the receiver. An additional extraction point was provided on both low-pressure turbines to supply surface type intermediate heaters. Hydraulic vacuum pumps and turbine-driven hotwell pumps were replaced by steam-jet ejectors and new motor-driven hotwell pumps. One condenser was retubed and relaned to reduce condensate refrigeration.

Feedwater System

Feedwater for the high-pressure boilers, picked up from the low-pressure feed-pump header at 275-lb. pressure and 250 F, is successively heated in the evaporator condenser and high-pressure heater (Griscom Russell) to 340 F. Three Worthington high-pressure boiler-feed pumps, 1,000 g.p.m. each, are driven by 1,135-hp. turbines supplied by 1,200-lb. pressure steam and exhausting at 220 lb.

Valves and Piping

"Carbon-moly" steel tubing is used for high-pressure steam and boiler-feed piping with welded joints except at machine connections. The archronograph has been used in making pipe welds, and stress relieving has been by induction furnace. No field X-ray examination has been made. Ten welded joints in the boiler recirculating system were examined with gamma rays by the boiler manufacturer. Shop welding of more complicated piping sections has been done insofar as possible, long lengths being delivered to the plant and welded in.

High-pressure valves are 1,500 lb. standard, but of cast carbon-moly steel with stainless-steel trim. Seat and disk faces are Stellited.

Auxiliary Drives

Except for the high-pressure boiler-feed pumps, all new auxiliaries are motor driven both for the new unit, and new auxiliaries added to the low-pressure turbines. All auxiliaries are being driven from the 60-cycle system, even though they serve 25-cycle generating equipment. Three 4,000-kva. transformer banks supply the metal-covered auxiliary bus equipment through double secondary windings, 2,300 volt and 440 volt. Primary supply voltage is 12,000 volts from the station 60-cycle bus.

Electrical

Very little new electrical construction has been required. The new generator feeds the existing 9,000-volt bus structure which is adequate to care for the added capacity.

Desuperheater and Reducing Valve

To protect the system against loss of load on the low-pressure units in event of the high-pressure turbine tripping out for any reason, a desuperheater and pressure reducing station (Republic Flow Meters Co.) is provided. Designed to bypass 700,000 lb. per hr. of 1,200-lb. steam around the high-pressure turbine, the desuperheater will quickly reduce both pressure and temperature to the conditions required by the low-pressure machines without much, if any loss of load. To provide extreme rapidity of action, $\frac{1}{2}$ sec. or less, two valves are used. One is a regulating valve continually adjusted while the high-pressure turbine is running to pass just the amount of steam flowing in the turbine. The other, a quick-acting valve, normally keeps the line tight closed but flies open if the turbine trips out. No moving parts are used to regulate water flow.

TABLE OF EQUIPMENT NOT AVAILABLE

WATERSIDE

Waterside spans power history from the engines of 1901 to the 1400-lb., 900-F top of 1937. Full program will replace 92 boilers and 10 vertical turbines with 4 topping units exhausting to old 200-lb. condensing turbines across the street. Plant efficiency rises to modern levels, capacity from 366,000 kw. to over 500,000; flyash and smoke practically disappear; old equipment costing millions wins a new lease of useful life

WATERSIDE Station, 39th St., Manhattan, New York, N. Y., on the East River, is owned by Consolidated Edison Co. Original plant, Waterside No. 1, started in 1901, totaled 60,000 kw. in 11 engines and 3 vertical turbines. In 1905, adjacent No. 2 plant came into existence with a capacity of 80,000 kw. in 10 vertical turbo-generators. In the two stations a total of 152 boilers, in two decks, generated steam at 200 lb. Boilers were practically unchanged from birth to 1937, but the turbine plant evolved step by step. Waterside exemplifies the history of power development since engine days. In No. 1 all engines were replaced by turbines and all boilers were equipped with superheaters and underfeed stokers. More than 20 years ago two of the original turbines in No. 2 were replaced with larger horizontal units.

Link to Past Design

As of 1936, Waterside No. 1 had a generating capacity of 214,000 kw., with 9 turbines and 54 (originally 56) boilers. No. 2 had 152,000 kw. with 10 turbines and 92 boilers. Connected by steam, water and electric lines, the two houses had a combined capacity of 366,000 kw., with 19 turbines and 146 boilers. In 1936 it was still at Metropolitan load center, as in 1904.

Many features of the new installation were predetermined by existing layout. Waterside No. 1 had relatively good turbine equipment. Boilers in both No. 1 and No. 2 were of ancient vintage. No. 2 afforded a clear space after removal of eight vertical turbines, and had a larger building space, favorable to large new boilers. The situation logically called for nearly complete revamping of No. 2, with practically no change in No. 1. As a result, steam at 200-lb. pressure will be piped across the street and condensate will be returned through existing lines.

The program now under way will eventually eliminate 10 vertical turbines (114,000 kw. total) and the 92 boilers in Waterside No. 2, plus all auxiliaries and four 300-ft. smoke stacks. This will make room for four 1200-lb., 900-F, 60-cycle, 53,000-kw., topping turbo-generators exhausting at 200 lb. and 500 F (no reheating) to existing mains. The space of the 92 old boilers will be taken by eight 500,000-lb.-per-hour, 1400-lb., 900-F steam generating units.

Completion of the program will raise Waterside capacity to over 500,000 kw., and will ultimately change present 25-cycle current to 60-cycle.

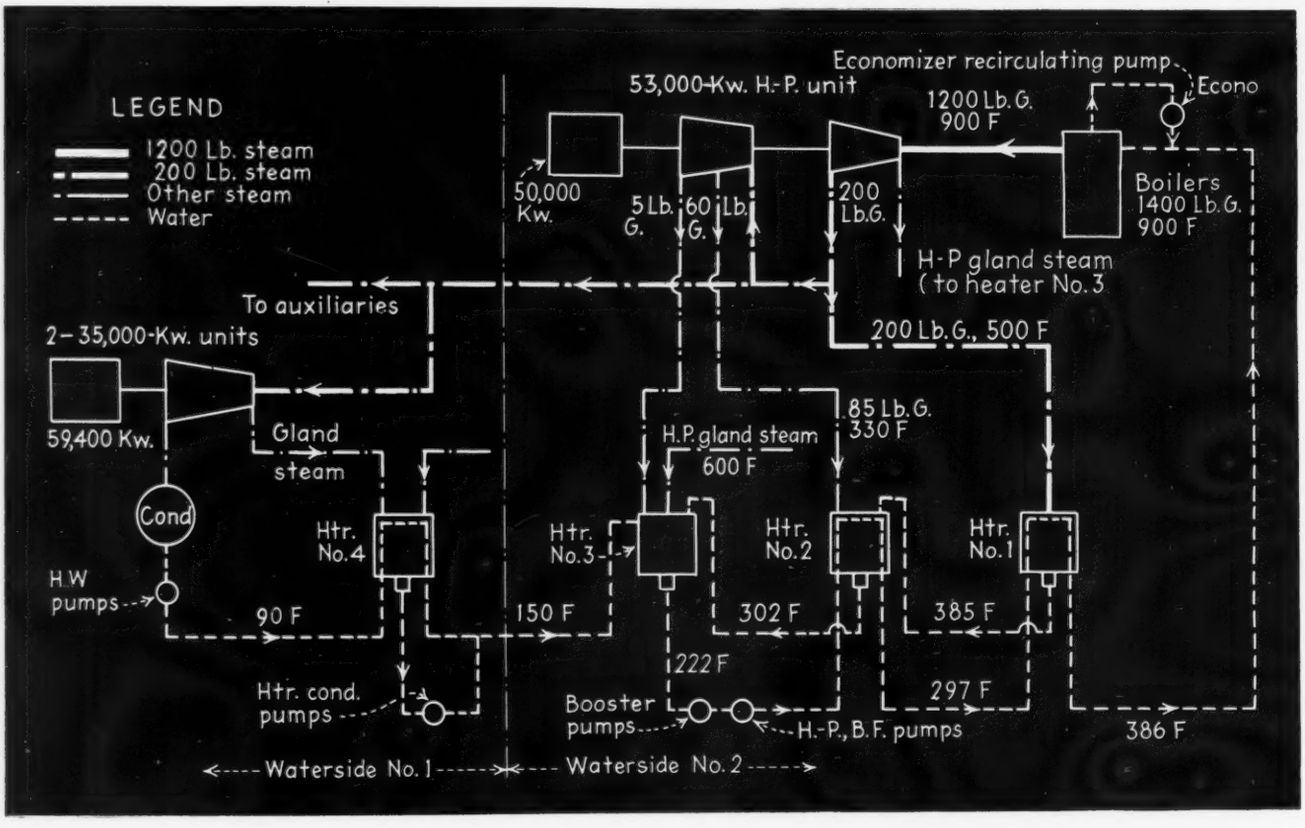
Present Construction

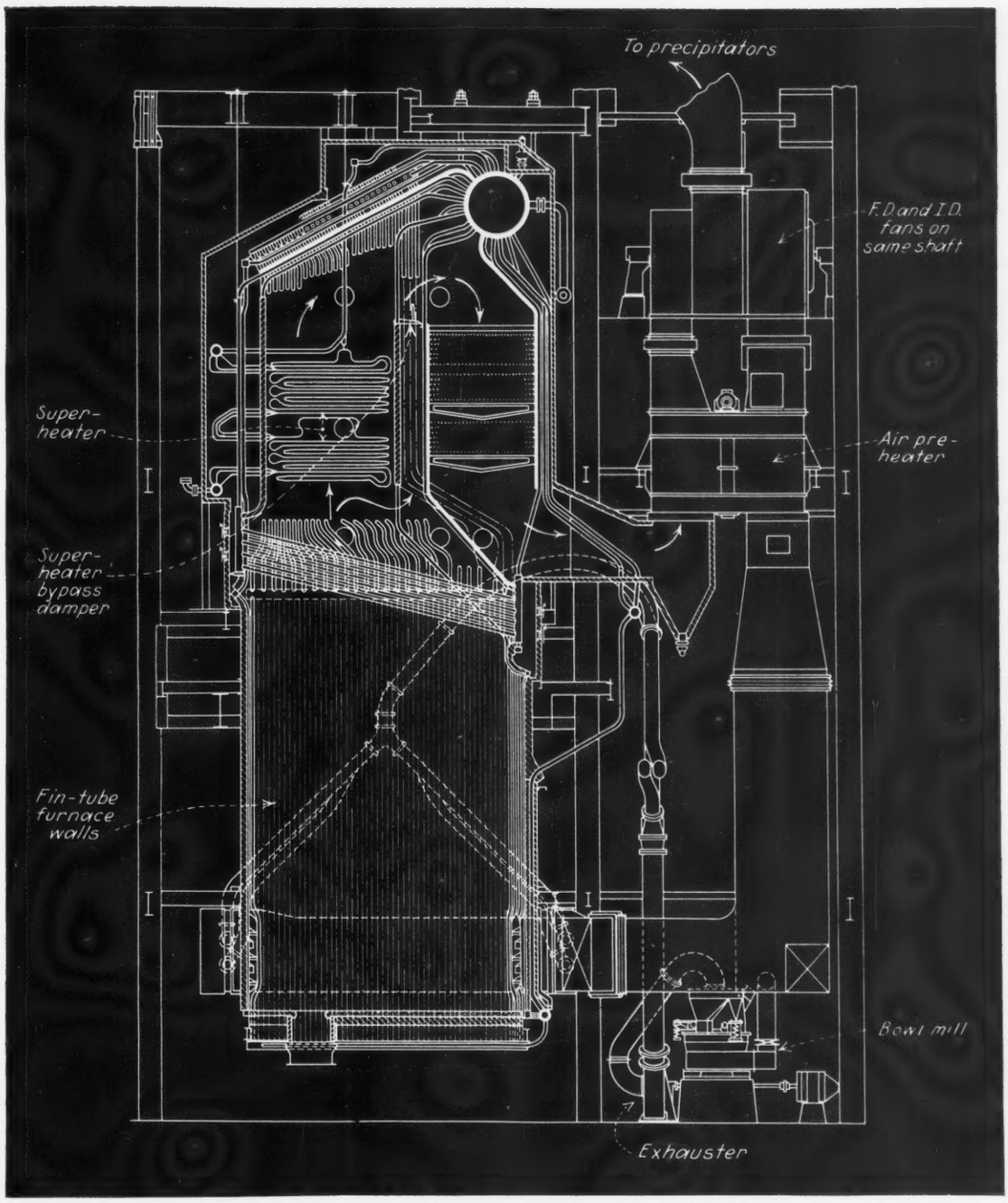
First unit (two boilers and one turbine) is nearing completion and second (similar capacity) is ordered. Eight vertical turbines and 60 boilers are already removed. Two 300-ft. stacks have been replaced by a single 450-ft. stack and 80,000 kw. of turbine capacity has been rewound for 60 cycles. Adaptation of new equipment to the old building at minimum cost demands many structural compromises.

Heat Balance

The turbine top in No. 2 will send most of its exhaust 400 ft. (across the street) to the low-pressure condensing turbines in No. 1. These, in turn, will send condensate back to No. 2 at about 150 F (heated by steam auxiliaries of No. 1). No. 2 will continue the feed heating (plus deaeration) by 5-lb. exhaust and 60-lb. bleed from a feed-heating turbine, a "Pek-

Flow diagram. Feature: "Pekingese" turbine supplies steam for feedwater heating.





Steam-generating unit: 500,000 lb. per hr. maximum capacity at 1350 lb. and 900 F

ingese" (snubnosed) innovation on end of the topping turbine shaft. Loading of this turbine will be determined solely by feed-heating needs.

Steam-Generating Units

Two Combustion Engineering Co., 500,000-lb.-per-hr., single-drum boilers will supply each turbine through individual welded steam lines joined at the turbine throttle. No steam interconnection will be made between units. A 6-high straight-tube boiler is hung 25 ft. below drum, allowing space for economizer and superheater. This straight-tube section contains only 7000 sq.ft. and will account for only 10% of the total heat absorption of the unit. Furnace extends 45 ft. below these tubes.

Leaving boiler tubes at 2000 F, gas passes up through superheater, then down through sinuous-tube economizer and out through regenerative air preheater, fans, and cinder catcher to stack. Lower superheater tubes are of chrome-molybdenum steel to withstand high temperature. Superheater bypass controls final steam temperature.

Furnace and Firing

Eight duplex pulverized-coal burners (two in each corner) fire tangentially downward toward continuous slag-top bottom, selected to reduce flyash and combustible loss. Furnace is designed for heat release of 30,000 B.t.u. per cu.ft. Fin-tube waterwalls are 40 ft. high, completely encircling the 20x23-ft. floor. Each of two mills feeds four burners.

Coal, Ash, Smoke, Flyash

Existing coal-handling facilities are retained, supplemented by a new "run-around" conveyor serving any mill from any bunker gate. Each mill has its own weigh scales. Slag, continuously tapped, is wetted and elevated by bucket conveyor to existing ash cars. Flyash from electrical precipitators is pneumatically conveyed, then dampened for delivery to scows.

Economizer, sinuous-tube, is within the setting. Regenerative air preheater in rear of boiler preheats air to 509 F. Gas leaves economizer at 619 F, and air heater at 292 F.

Location of plant near Murray Hill shopping and residential section requires effective smoke prevention and flyash removal. To prevent smoke, heat liberation is kept under 30,000 B.t.u. per cu.ft. and illuminating gas is burned until boiler is on line. Three sections of electrostatic precipitator have highest flyash removal efficiency market affords. A mechanism removes flyash from hoppers continuously; air-

operated dampers isolate each section for periodic scraping. Finally, the exceptionally clean flue gas is discharged at the top of a 450-ft. stack, towering well above neighboring buildings.

Turbine

First 53,000-kw., 3600-r.p.m. Westinghouse superposed turbine nears completion. Generator is 58,800 kva., hydrogen cooled, explosion proof. So-called feed-heating turbine on same shaft with main turbine (beyond governor-end bearing) contributes 3500 kw.; main unit 49,500 kw. Main turbine has two impulse wheels and 14 pressure stages expanding from 1200 lb. gage to 200 lb. Feed-heating turbine has 8 stages from 200 lb. to 60-lb. bleed point and 11 stages more to 5-lb. gage exhaust, which goes only to deaerating heater. Second turbine on order with General Electric Co. is of similar design.

Governor is latest hydraulic type with bar-lift arrangement. Main-unit flow is controlled to hold 200-lb. exhaust pressure in addition to speed governing; feed-heating turbine flow is regulated to hold 5-lb. pressure at exhaust.

For normal starting, boilers are brought up from cold to start turbine rolling slowly at low pressure. Speed increases as pressure rises. First steam passes through high-pressure turbine and feed-heating unit (in series) to deaerator, excess exhausting to atmosphere there. At 2400 r.p.m., turbine begins to feed 200-lb. main. Then unit is brought to 3600 r.p.m. and synchronized.

Heaters and Deaerator

Condensate from turbines in Waterside No. 1, heated to 150 F by auxiliary exhaust, passes back to deaerator (in No. 2 boiler house), supplied from exhaust of feed-heating turbine. In same boiler house are two 500,000-lb. per hr. vertical intermediate heaters. They operate in parallel and are supplied with 60-lb. steam bled from the feed-heating turbine. Two high-pressure heaters, also vertical and in parallel, use 200-lb. main-turbine exhaust. With one intermediate and one high-pressure heater out of service, booster pumps assist boiler-feed pumps.

Valves and Piping

All piping is welded where possible, even small drain and condensate lines. The 1400-lb. steam main is 12-in. nominal, carbon-moly steel. Valves have cast bodies with stainless-steel discs and seats.

Auxiliary Drives

Auxiliaries are motor driven, except emergency feed pump. Constant-speed motors throughout, including feed pumps and fans. One forced- and one induced-draft fan on same motor shaft, vanes controlling flow. Two such combinations serve each boiler.

Electrical

Generator, with shaft exciter, is wound for 13,000-volt transmission voltage. Switch house, heritage of 1905 design, is 13 ft. wide. Each new generator is to feed a stub bus having eight feeders. All switching equipment is metal covered.

PRINCIPAL EQUIPMENT IN WATERSIDE STATION
Consolidated Edison Co., New York, N. Y.

Boilers and waterwalls.....Combustion Engineering Corp.
Boiler, heating surface, 7,003 sq.ft.; water walls, 7,548 sq.ft.; max. continuous steaming cap. each, 500,000 lb. per hr.; working pressure, 1,350 lb. G.; total steam temp., 900 F; furnace volume, 20,300 cu.ft.; max. B.t.u. liberated per cu.ft. per hr., 30,000.
Superheater, Elesco, 14,000 sq.ft. per boiler.....Superheater Co.
Economizer, Elesco, 18,850 sq.ft. per boiler.....Superheater Co.
Economizer recirculating pumps.....Foster Wheeler Co.
Steam washer inside drum.....Combustion Engineering Corp.
Air heater, 32,700 sq. ft. per boiler.....Air Preheater Corp.
Boiler and furnace settings.....Combustion Engineering Corp.
Boiler heat insulation.....Refractory & Insulation Corp.
Boiler ducts and breechings.....M. H. Treadwell Co.
Stack, steel, brick-lined.....M. H. Treadwell Co.
Structural-steel contractor.....M. H. Treadwell Co.

COMBUSTION EQUIPMENT:

Automatic combustion control.....General Regulator Co.
Combustion-control oil pumps.....Tuthill Pump Co.
Soot-blowers.....Diamond Power Specialty Corp.
Pulverized-coal burners, 8 per boiler; cap. each, 5,600 lb. per hr.....Combustion Engineering Corp.
Ignition torch, gas.....Combustion Engineering Corp.
Coal pulverizers, Raymond, 2 per boiler; cap. each, 22,800 lb. per hr.....Combustion Engineering Corp.
Drive, 150-hp., 1,200-r.p.m., 2,300-volt squirrel-cage motors.....Elliott Co.
Mill exhauster, integral.....Combustion Engineering Corp.
Coal feeders, 2 per boiler.....Combustion Engineering Corp.
Motor, 1.5 hp., "Speed-trol" drive...Sterling Electric Motors, Inc.
Forced-draft fans, 2 per boiler; cap. each, 87,000 c.f.m. at 80 F; static pressure 9.75 in., vane control.....B. F. Sturtevant Co.
Drive, 600-hp., 690-r.p.m. squirrel-cage motor.....Elliott Co.
Flexible coupling between fan and drive...Bartlett Hayward Co.
Induced-draft fans, 2 per boiler; cap. each, 139,000 c.f.m. at 231 F; static pressure 12.5 in.....B. F. Sturtevant Co.
F.d. and i.d. fans arranged as duplex units, one f.d. and one i.d. fan on same shaft driven by a single motor; two duplex units per boiler.

COAL-HANDLING EQUIPMENT:

Bunker coal conveyor, Redler.....Stephens Adamson Co.
Magnetic separator.....Cutler-Hammer Inc.
Coal scales.....Richardson Scale Co.
Coal gates.....Allen-Sherman Hoff Co.

ASH-HANDLING EQUIPMENT:

Ash-handling equipment on furnace, continuous slag tap
Slag conveyors.....Combustion Engineering Corp.
Ash-handling equipment on flyash system, pneumatic.....United Conveyor Corp.
Vacuum pumps, flyash-removal system.....Nash Engineering Co.
Ash and soot precipitator, Cottrell.....Research Corp.

VALVES:

Boiler safety valves.....Consolidated Ashcroft Hancock Co.
Superheater safety valves.....Crosby Steam Gage & Valve Co.
Blowdown valves.....Edward Valve & Mfg. Co.
Non-return valves.....Edward Valve & Mfg. Co.
Turbine quick-opening valve for feed pump.....Atwood Morrill Co.
Non-return valves on turbine bleed lines.....Jenkins Bros.
Oil-closing, turbine-bleeder valve.....Edward Valve & Mfg. Co.
Stop and check valves in feed lines.....Chapman Valve Mfg. Co. and Edward Valve & Mfg. Co.
High-pressure valves.....Chapman Valve Mfg. Co.
Medium-pressure valves.....Chapman Valve Mfg. Co., Crane Co., and Wm. Powell Co.
Low-pressure valves.....Crane Co.
Electric valve operators, Limitorque.....Philadelphia Gear Works

PIPING, TRAPS AND STRAINERS:

Piping fabricator.....W. M. Kellogg Co.
Piping erector.....M. H. Treadwell Co.
Pipe heat insulation..Johns-Manville, and Refractory & Insulation Corp.
High-pressure traps.....Atwood and Morrill Co.
Low-pressure traps.....Atwood and Morrill Co.

FEEDWATER SYSTEM:

Water columns.....Diamond Power Specialty Corp.
Feedwater regulators.....Republic Flow Meters Co.
Boiler-feed pumps, 3 per unit, 2 motor and 1 turbine driven; cap. 1,250 g.p.m. each, 3,350-ft. head Worthington Pump & Mach. Co.
Feed-pump drive, two 1,500-hp., 3,580-r.p.m., squirrel-cage motor.....Allis-Chalmers Co.
one 1,800-hp., 3,550 to 3,750-r.p.m., steam turbine.....Moore Steam Turbine Co.
Boiler-feed booster pumps, 2; cap., 1,250 g.p.m. each, 460-ft. head.....Worthington Pump & Mach. Co.
Distilled-water pump.....Worthington Pump & Mach. Co.
Distilled-water cooler.....Westinghouse Elec. & Mfg. Co.
Feedwater-deaerating heater.....Elliott Co.
Feedwater heaters.....Foster Wheeler Co.
Feedwater-heater drainage regulator.....Atwood & Morrill Co.
Heater condensate pump, 1; cap. 100 g.p.m.; 100-ft. head..Dean Bros.
Feedwater-heater drainage regulator.....Atwood & Morrill Co.
3,300-ft. head.....Worthington Pump & Mach. Co.

METERS:

Boiler meter and control board.....Bailey Meter Co.
Turbine meter and control board.....Westinghouse Elec. & Mfg. Co.
Turbine meter and control board.....General Electric Co.
Boiler meters.....Bailey Meter Co.
Steam flowmeters.....Bailey Meter Co.
Steam-flow and -pressure recorders.....Bailey Meter Co.
Feedwater flowmeters.....Builders Iron Foundry
Turbine-pressure gages, indicating.....Ashton Valve Co.
Turbine-pressure gages, recording.....Bristol Co.
Turbine-speed indicator.....James G. Biddle
Turbine-speed recorder.....Westinghouse Elec. & Mfg. Co.
Thermometers, industrial.....Palmer Co.
Thermometers, resistance.....Illinois Testing Laboratories
Temperature recorders.....Leeds & Northrup Co.
Pyrometers.....Illinois Testing Laboratories
Draft gages.....Bailey Meter Co.
Draft gages, multiple point.....Bailey Meter Co.
Steam-pressure gages, indicating.....Ashton Valve Co.
Water-pressure gages.....Ashton Valve Co.

GENERATING UNITS:

Two, 53,000-kw., 3,600-r.p.m. turbines; throttle steam conditions 1,200 lb., 900 F.; automatic extraction at 5-60-200 lb. G. pressure at exhaust 200 lb. G.....1-Westinghouse Elec. & Mfg. Co.
1-General Electric Co.
Turbines connect to 58,800-kva., 0.90-p.f., 3-phase, 60 cycle, 13,800-volt generators.....1-Westinghouse Elec. & Mfg. Co.
1-General Electric Co.
Generator hydrogen coolers.....1-Westinghouse Elec. & Mfg. Co.
1-General Electric Co.
Oil coolers.....1-Westinghouse Elec. & Mfg. Co.
1-General Electric Co.
Oil-cooler water pumps.....Fairbanks-Morse Co.
Condensate booster pumps, 3, two motor and one turbine drive; 1,000 g.p.m.; 96-ft. head.....Goulds Pump Inc.
Condensate booster-pump drive, 30-hp., 1,750-r.p.m., 208-volt squirrel-cage motors.....General Electric Co.
Condensate booster-pump turbine.....Terry Turbine Co.

SCHUYLKILL

A 50,000-kw. high-pressure, high-temperature, turbo-generator with its complement of two 600,000-lb. per hr. pulverized-fuel-fired boilers exhausts primarily to three 215-lb., 150-F superheat units totalling 85,000 kw., displacing 24 low-pressure boilers and a 15,000-kw. vertical condensing turbine. Top provides increased capacity without additional circulating water

SCHUYLKILL station, 1½ miles southwest of City Hall, Philadelphia, at 27th and Christian Sts., is one of seven principal generating stations of the Philadelphia Electric Co. system. First operated in 1903, the station was enlarged in 1912 and 1915 to a total available plant capacity 129,000 kw. Present program provides for installation of a 50,000-kw. high-pressure, high-temperature turbine-generator with its complement of boilers exhausting primarily to three 215-lb., 150-F superheat units totaling 85,000 kw. The new 50,000-kw. unit, No. 3, occupies space previously taken by a 15,000-kw. vertical condensing unit. Of 40 low-pressure boilers on two floor elevations in boiler room No. 1, 24 are being replaced by two 600,000-lb. per hr. high-pressure pulverized-fuel-fired steam-generating units. Boiler room No. 2, containing 20 low-pressure boilers, remains practically unchanged except for conversion of ten stoker-fired units to oil firing. New top turbine is located in turbine room No. 1, while turbine room No. 2 is practically unchanged except for installation of two deaerating heaters and first-stage heaters connected to turbine bleed points on two existing units.

Circulating Water Limited

The plant is on the Schuylkill River, about two miles below a dam. Part of city water requirements are taken from above this dam. Occasionally during the summer no flow is available over the dam, necessitating dependence on surface evaporation for cooling effect. Topping unit provides increased capacity without requiring additional circulating water and is therefore particularly well suited to Schuylkill. Like many other tops, existing land, building and general facilities are utilized to their fullest extent. Superposition study showed investment fully justified by operating savings in fuel, labor and maintenance; not only is additional capacity provided for the system by the present program, but Schuylkill is located at a strategic point for system reinforcement, added capacity affording improved reliability.

Single 50,000-kw. topping unit only is planned for the present, although layout has been so arranged that additional capacity can be added within the building if warranted later by load conditions. Further extension of the station will depend considerably on study of river temperature after first unit operates through a summer period. While topping unit does not of itself increase circulating-water requirements, increased heat dissipation will accompany base-load operation of existing condensing units.

Unit size and steam conditions were chosen so that when high-pressure turbine has a base load of 50,000 kw., three low-pressure units (85,000-kw. capacity) will operate at their most economical aggregate loads. Of the three low-pressure turbines, the 20,000- and 30,000-kw. units are 1,500-r.p.m., 25-cycle machines and the 35,000-kw. unit is 1,200-r.p.m., 60-cycle.

Station heat rate in previous years of normal operation was about 22,000 B.t.u. per kw.-hr. High-pressure addition will result in performance of approximately 11,800 B.t.u. per kw.-hr., shifting Schuylkill from standby to base-load operation.

Demolition of 24 low-pressure boilers and building wall of No. 1 boiler house is complete and steel erection is in progress. Removal of boiler-house walls, necessary because of changed column spacing and heavier columns for new boilers, simplifies construction work on foundations and steel. In the turbine room, 15,000-kw. vertical turbine has been removed.

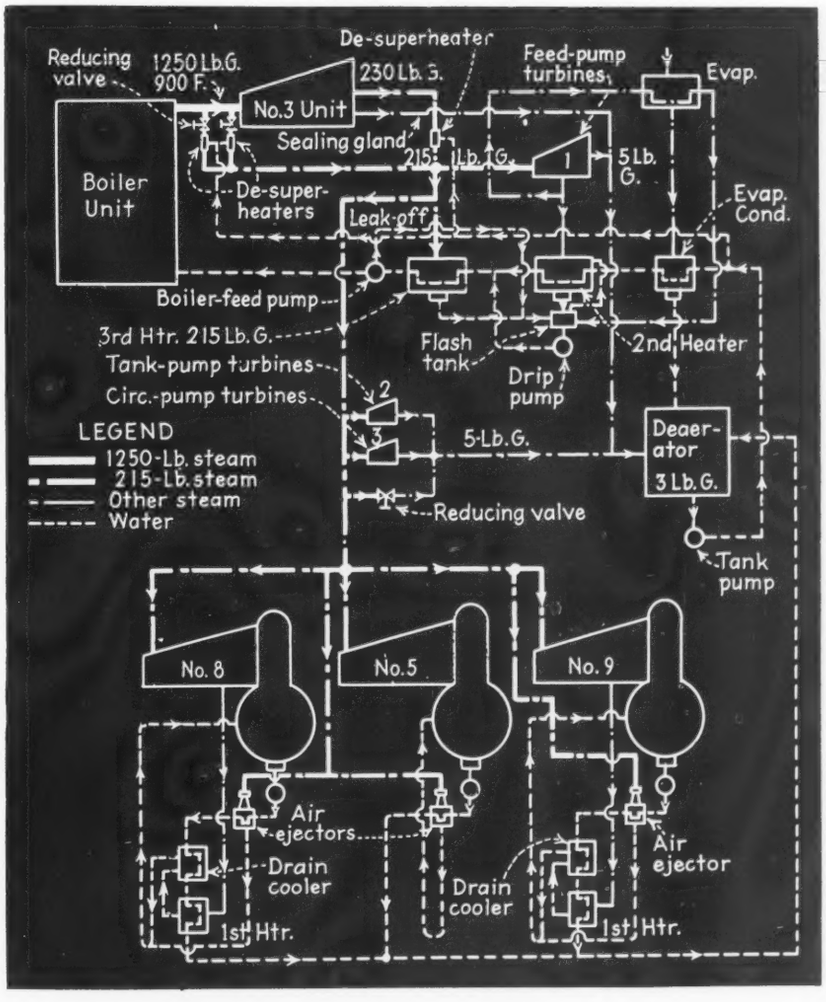
Conversion of ten low-pressure boilers in boiler house No. 2 to oil burning is nearly complete. These may be kept for hot standby during peak periods after high-pressure unit starts operation. With oil, these ten will each be rated at approximately 80,000 lb. per hr.

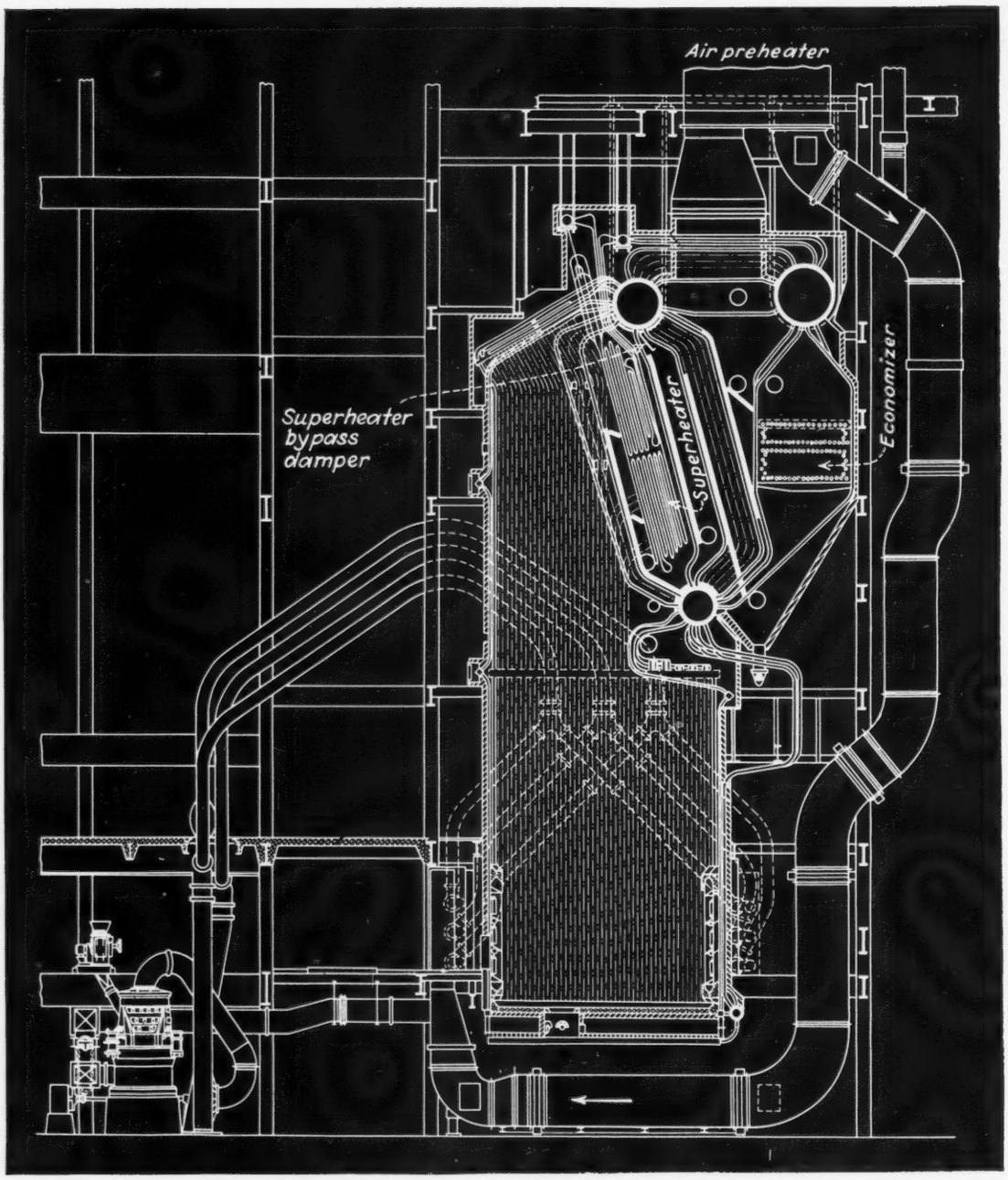
Engineering by Philadelphia Electric Co. is not entirely finished; equipment table for Schuylkill is therefore incomplete as respects other than principal items.

Steam-Generating Units

Two Combustion, 1,350-lb., 910-F, bent-tube, 3-drum generating units

Flow diagram. Feature: Boiler-feed turbine bleeds for second-stage heater





Steam-generating unit: 600,000 lb. per hr. max. capacity at 1,250 lb. and 900 F

are rated at 600,000-lb. per hr. each. The upper rear drum is provided with a steam washer. Three pulverized-coal burners in each corner of the furnace are arranged for tangential firing by the unit system and are supplied by three 15-ton per hr. bowl mills. Continous slag-tap furnace has a volume of 27,300 cu.ft. Oil fuel will bring boilers up to pressure.

Boiler contains 11,193 sq.ft. of heating surface, superheater 16,300, and economizer has 11,500. Superheater bypass-damper control maintains total temperature of steam within 10 F, from three-quarter to full load. Continuous loop economizer is fully counterflow, gas upward and water downward. Two 27,500-sq.ft. Ljungstrom air preheaters per boiler, completing the heat-absorbing surface, are equipped with soot blowers for cleaning by steam and water.

Forced and Induced Fans

Two induced-draft fans per boiler discharge 375,000 c.f.m. of 385-F gas against 23 in. w.g. Each fan is driven by 1,000-hp. squirrel-cage, constant-speed motor through a hydraulic coupling for speed control. Forced-draft fans can operate against a static pressure of 14 in. w.g., and are driven by 350-hp. motors through hydraulic couplings.

Hydraulic couplings, after successful experience at Richmond Station on fans and condensate pumps, are of modified design. Separate bearings on both sides of the coupling unit provide for ready dismantling; older design with part of coupling carried on outboard end of motor bearing required moving motor for disassembly. Each coupling is a unit with individual oil control by rotary gear pump and oil cooler sufficient to keep oil temperature below 150 F in normal operation.

Urban location of plant, near University of Pennsylvania and residential section, led to selection of electrostatic precipitators for flyash removal after satisfactory experience at Richmond Station with this type of equipment. Three sections wide and two sections deep for each boiler, precipitators are between air heaters and induced-draft fans to reduce fan-wheel erosion. Gas velocities in ductwork and stack have been kept at low levels to aid removal of flyash content of flue gas.

Single-cyl. Westinghouse turbine is

rated at 50,000 kw. at 3,600 r.p.m. Pressure regulator maintains exhaust at 230 lb. gage. One impulse element (two velocity stages) is followed by 14 reaction stages. Turbine, generator and exciters are 46 ft. 8 in. long. Throttle valve of inverted type adds over 7 ft. 2 in. to length, making 53 ft. 10 in. over all.

Generator is hydrogen-cooled with internal propeller-type fans mounted on the shaft and surface coolers inside generator housing. Rating is 50,000 kw. at 85% power factor, 13,800 volts.

Heat Balance

Heat balance was dictated to a considerable extent by existing features of the plant. Two of the three low-pressure turbines which will normally operate from the higher-pressure turbine exhaust can be conveniently arranged for bleeding. The third cannot be economically equipped. The two first-stage heaters will normally heat condensate from the two units to about 150 F. Condensate from the third unit will be sent to the deaerator at little more than hotwell temperature. Part of the steam for the deaerating heater is supplied by exhaust from turbine-driven boiler-feed pumps and tank pumps at 5-lb. gage. Additional steam is available from circulator drives, two of which are turbine- and motor-tandem drive. By controlling load between motor and turbine on two of five circulators, an exhaust balance is obtained.

Second-stage heaters are supplied with steam at about 70-lb. pressure from a bleed point on the 2,000-hp. boiler-feed turbine. This arrangement was determined after careful study of other available methods of supplying feedwater heating steam and requires a special design of turbine to produce the power requirement of the pumps with varying quantities of bled steam.

As the boiler-feed pump turbine develops only about 1,000 hp. nonbleeding, a reliable heater system is necessary to insure ability to absorb bleed steam at all times. Heaters and evaporators are therefore installed in duplicate, each row designed for about three-quarters of full load on the topping unit. In an emergency, a single set of heaters can carry full load of the boilers with some loss of efficiency. Piping and valves in feed lines are simplified by eliminating bypasses around individual heaters; an entire set of heaters being taken out of service by two valves.

Bleed point of boiler feed-pump turbine also supplies evaporator steam for a 50,000-lb. per hr. double-effect evaporator. Makeup will be introduced at convenient times, storage capacity being sufficient to avoid the necessity of continuous operation of evaporators. Operation of evaporators disturbs balance of bleed steam from boiler feed-pump turbine very little as practically all heat is returned to the system through evaporator condensers ahead of second-stage heaters.

Third-stage heaters are supplied by 215-lb. steam from the high-pressure turbine exhaust, feedwater temperature to economizers remaining approximately constant at 390 F over full turbine-load range.

Three boiler-feed pumps and three deaerator-tank pumps are installed, only two of each being required for full load on the high-pressure boilers. Turbines driving these pumps operate on 215-lb. steam. Tank pumps develop 410-lb. pressure in feedwater system, sufficient to carry through all heaters and avoiding necessity of building heaters for high pressure on the water side. Tank pumps operate at constant speed, final boiler feedwater pressure being regulated by speed variation of main feed pumps.

Two desuperheaters and reducing valves make the entire high-pressure boiler capacity available to the low-pressure turbines.

High-pressure steam piping will be Schedule 160 carbon-molybdenum tubing with welded joints, except where connection is made to equipment. Valves will be cast carbon molybdenum, welded in the line.

The new generator is wound for 13,800-volt bus potential and will tie into the present switching equipment, which will not require extension directly due to added capacity. Present flat copper bus will be changed to channel construction to provide additional capacity. Motor-driven auxiliaries are supplied from new metalclad switchgear.

PRINCIPAL EQUIPMENT IN SCHUYLKILL STATION

Philadelphia Electric Co., Philadelphia, Pa.

Boilers and waterwalls.....Combustion Engineering Co., Inc.
Boilers, two; heating surface each, 11,193 sq. ft.; waterwalls each, 8,050 sq. ft.; max. continuous steaming cap. each, 600,000 lb. per hr.; working pressure 1,350 lb. G.; total steam temp., 910 F; furnace volume, 27,300 cu.ft.; max. B.t.u. liberated per cu.ft. per hr. 27,300.
Superheater, 16,300 sq.ft. .....Superheater Co.
Economizer, 11,500 sq.ft. .....Combustion Engineering Co., Inc.
Steam washer, screen type.....Combustion Engineering Co., Inc.
Air heaters, 27,500 sq.ft. each, 2 per boiler.....Air Preheater Corp.
Boiler and furnace settings.....Combustion Engineering Co., Inc.
Furnace refractories .....American Arch Co.
Refractory brick .....Harbison-Walker Refractories Co.
Structural steel .....Lehigh Structural Steel Co.

COMBUSTION EQUIPMENT:

Automatic combustion control.....not let
Soot-blowers .....not let
Pulverized-coal burners, 12 per boiler.Combustion Engineering Co., Inc.
Coal pulverizers, 3 per boiler;Raymond bowl with integral exhausters; cap. each, 15 tons per hr. Combustion Engineering Co., Inc.
Pulverizer driving motor, squirrel-cage, 250-hp., 1,200-r.p.m., 2,300-volt .....General Electric Co.
Coal feeder, 1 per mill, variable-speed device with constant speed motor .....not let
Coal-feeder driving motor.....not let
Ignition torch .....not let
Forced-draft fans, 2 per boiler; cap. each, 102,500 c.f.m.; static pressure 14 in. .....American Blower Corp.
Forced-draft-fan drive, 350-hp., 1,200-r.p.m., squirrel-cage motor General Electric Co.
Connection between fan and drive, hydraulic coupling American Blower Corp.
Induced draft fans, 2 per boiler; cap. each, 187,500 c.f.m.; static pressure 23 in. .....American Blower Corp.
Induced-draft-fan drive, 1,000-hp., 900-r.p.m., squirrel-cage motor General Electric Co.
Connection between fan and drive, hydraulic coupling American Blower Corp.
Ash and soot precipitator, Cottrell type.....Research Corp.
Safety valves .....Consolidated Ashcroft Hancock Co.

FEEDWATER SYSTEM:

Boiler-feed pumps, 3; capacity each, 1,700 g.p.m.; 3,000-ft. head Ingersoll-Rand Co.
Feed-pump drive, 2,000-hp., non-condensing bleeder turbines, variable speed .....Elliott Co.
Tank pumps, 3; cap. each 1,300 g.p.m.; 940-ft. head Ingersoll-Rand Co.
Tank-pump drives, constant-speed, non-condensing turbines Elliott Co.
Evaporator, double-effect, 50,000-lb. per hr.....Foster Wheeler Corp.
Feedwater-deaerating heaters, 2, open type.....Cochrane Corp.
Drain coolers, 2, cap. each, per hr., 371,000 lb. condensate 25,900 lb. drain .....Cochrane Corp.
Evaporator condenser .....Alco Products Co.
Feedwater heaters, 2; cap. each, per hr. 371,000 lb. condensate Cochrane Corp.
Feedwater heaters, 2, cap. each, per hr. 680,000 lb. condensate Alco Products Co.
Feedwater heaters, 2, cap. each, per hr. 845,000 lb. condensate Alco Products Co.

GENERATING UNITS:

One, 50,000-kw., 3,600-r.p.m., steam turbine; throttle conditions, 1,250 lb. G., 900 F exhaust at 230 lb. G. Westinghouse Elec. & Mfg. Co.
Turbine connects directly to 58,824-k.v.a., 0.85 p.f., 3-phase, 60-cycle, 13,800-volt generator.....Westinghouse Elec. & Mfg. Co.
Desuperheater on turbine exhaust.....Republic Flow Meters Co.
Automatic desuperheater control.....Republic Flow Meters Co.
Generator hydrogen cooler.....Westinghouse Elec. & Mfg. Co.
Oil cooler .....not let
Oil purifier .....The DeLaval Separator Co.
Automatic voltage regulator.....Westinghouse Elec. & Mfg. Co.
Station transformers .....Allis-Chalmers Mfg. Co.
Station lighting transformers.....not let
Oil circuit breakers .....not let
Air circuit breakers.....Westinghouse Elec. & Mfg. Co.
Station auxiliary and lighting conductors.....Kerite Co.
Station auxiliary and lighting conductors.....General Cable Corp.
Station auxiliary and lighting conductors ..Simplex Wire & Cable Co.
Station auxiliary and lighting conductors..Rockbestos Products Corp.
Electric elevators .....Atlantic Elevator Co., Inc.

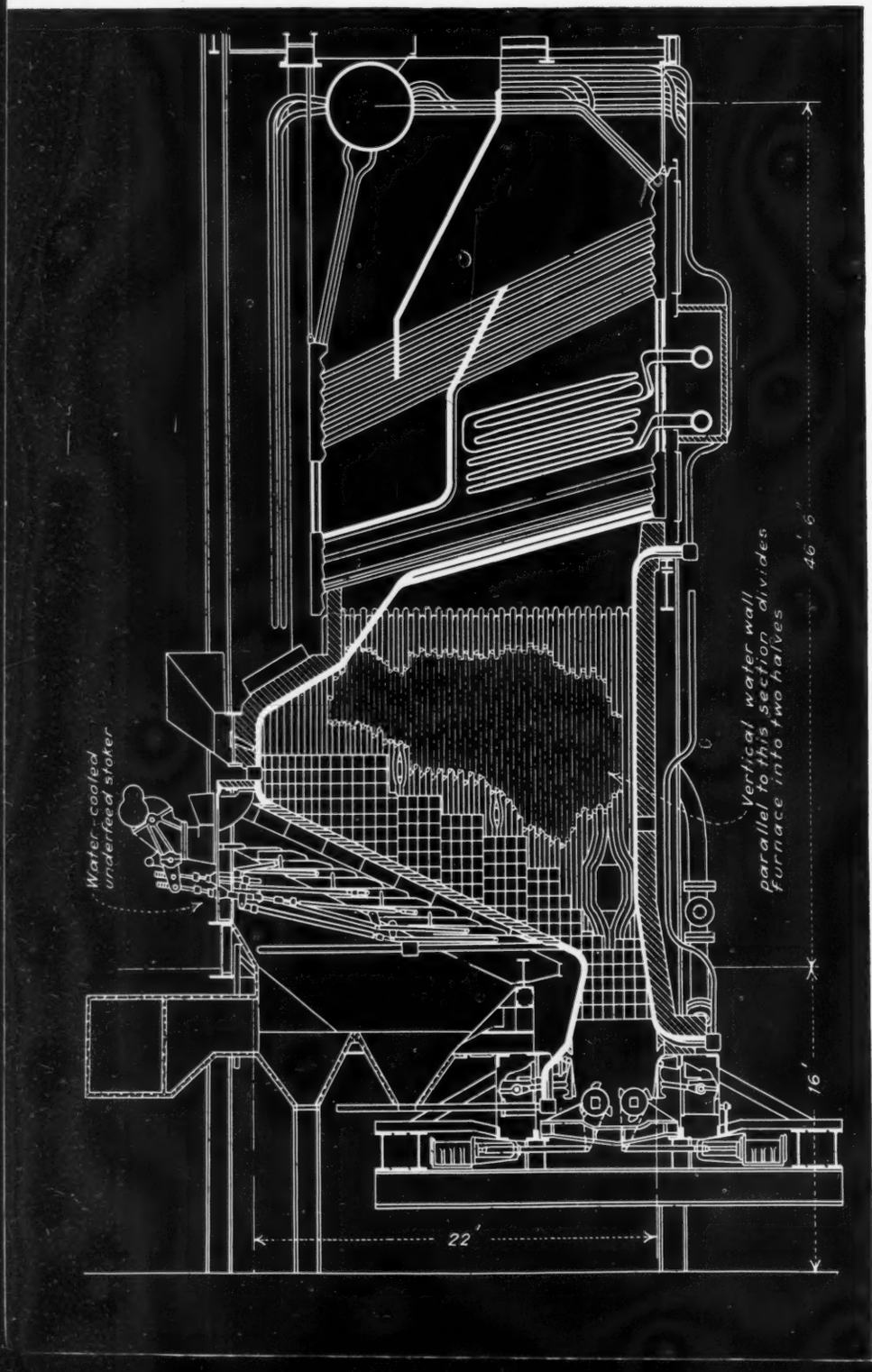
CEDAR RAPIDS

Demand for steam at 100- and 10-lb. pressures for industrial use and city heating helps justify topping turbine. Water-cooled stoker burns low-fusion-ash coal

CEDAR RAPIDS station of the Iowa Electric Light & Power Co. furnishes large quantities of 100-lb. steam for industrial purposes and 10-lb. steam to a central-heating system. Station operating heat balance varies with the season, weather and industrial activity as well as electric load. These factors obviously favor a superposed installation for modernization as well as increasing capacity. A 300,000-lb.-per-hr. steam-generating unit will soon be placed in operation supplying a 5,000-kw. turbine to exhaust at 215 lb., 150 F superheat directly into the existing 210-lb. station header.

Present station has installed, in addition to new top, five turbines aggregating 37,000 kw. One of these is a 6,000-kw. non-condensing unit bled at 100 lb. to supply the nearby Quaker Oats Co. plant and exhausting at 10 lb. to the city heating system.

Steam-generating unit: 300,000-lb.-per-hr. max. capacity at 675 lb. and 765 F



Several years ago, availability of low-fusion-ash (1900 F) coal from Atkinson, Ill., led to cooperation between the Iowa Electric Light & Power Co. and the American Engineering Co. in experiments at Cedar Rapids with water-cooling of stoker tuyeres. After two years' experience in burning low-fusion-ash coal on eight stokers at coal-burning rates up to 55 lb. per hr. per sq.ft. of air-admission section, the water-cooled stoker has thoroughly demonstrated its ability to burn the low-fusion-ash coal with preheated air. The new steam-generating unit will be fired by an underfeed stoker, water cooled and using air preheated to 450 F.

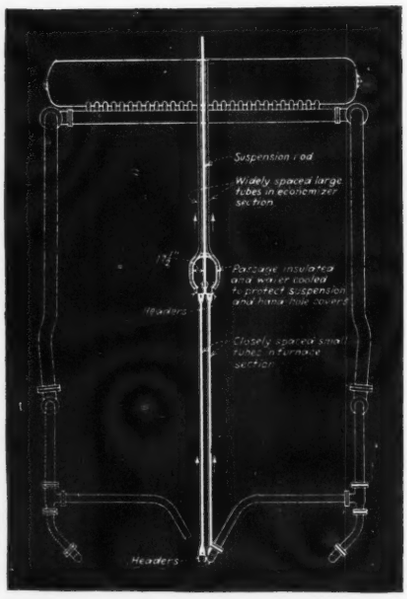
Steam-Generating Unit

The new 13,600-sq.ft. Springfield boiler rated at 300,000-lb.-per-hr. is a cross-drum, 3-pass, straight-tube type with interdeck Elesco superheater. Tubes in the lower bank slope at 15 deg. from the horizontal while those in the upper bank slope at 25 deg. This arrangement facilitates tube removal and gives better circulation in the upper bank. A slag screen 17 in. deep can be deepened, if necessary to 27 in. The all-welded drum is 54 in. inside diameter and 30 ft. long.

The furnace, completely water-cooled by closely-spaced 3-in. water wall tubes, is divided in half by a double waterwall perpendicular to the axis of the drum. This wall extends from below the stoker to within the superheater zone and increases greatly the radiation from the fuel bed.

The stoker, nominally 14 retorts wide, is in reality two 7-retort stokers side by side separated by the waterwall. The stoker has 543 sq.ft. of

Double screen of water-cooled tubes divides furnace, increasing radiant absorption from fuel bed


Suspension rod
Widely spaced large tubes in economizer section
Porcelain insulated and water cooled to protect suspension and hand hole covers
Headers
Closely spaced small tubes in furnace section
Headers

surface (air-admission part only) and is not equipped with metered air control although provision is made for its installation if later proved desirable. It is expected to burn about 68 lb. per hr. of 10,500-B.t.u. coal per sq.ft. of stoker area.

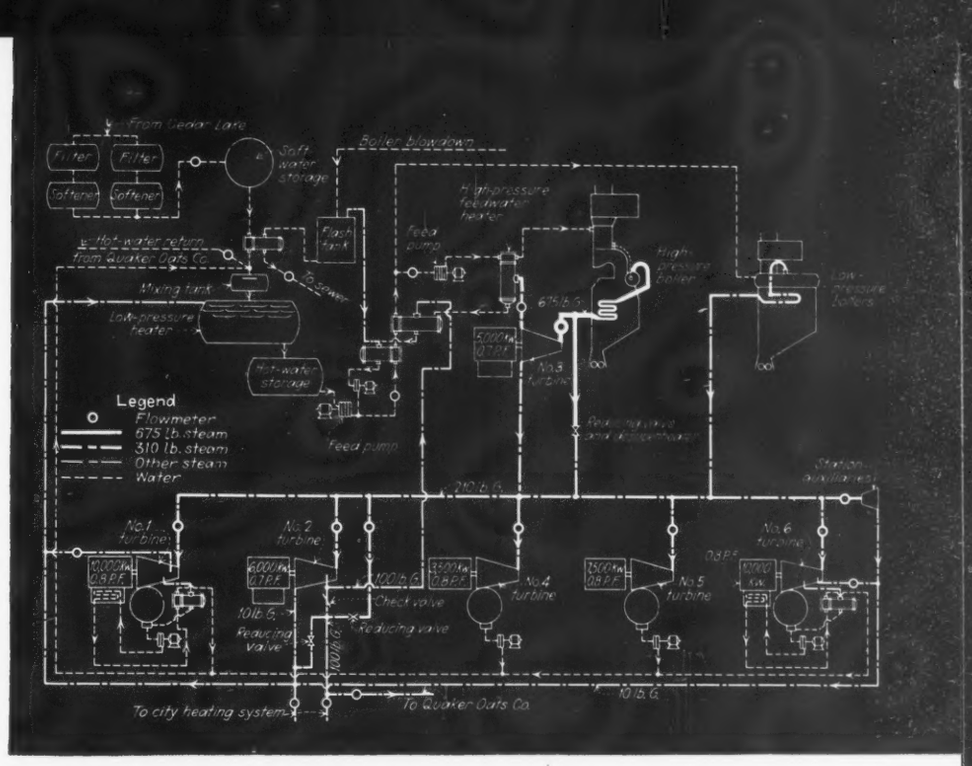
The water-cooled feature of the stoker was developed at Cedar Rapids and the eight stokers already so equipped are the first large scale application of the design. On the new stoker, water tubes (part of the waterwall circulation system) are located directly on top of the tuyere rows. The cooling effect acts to freeze the molten ash quite some distance up the fuel bed allowing unrestricted flow of air and proper functioning of the stoker.

The 4,600-sq.ft. extended-surface economizer is outside the boiler setting. A 20,500-sq. ft. Ljungstrom air heater completes the heat-absorbing surface. Forced-draft fans are vane controlled and induced-draft fans are equipped with a dust collector.

Turbine

The 7-stage 5000-kw. General Electric turbine operates at 3,600 r.p.m. and is direct-connected to a 0.70-p.f., 14,000-volt, air-cooled generator. Normally the turbine is controlled by a backpressure governor which determines the load carried by the unit depending on exhaust pressure required to give load priority.

A high-capacity reducing valve and desuperheating station bypasses the high-pressure turbine making the new boiler-plant capacity available to the low-pressure station.



Flow diagram. Feature: High-pressure cycle gets feedwater from existing boiler-feed header, returns 210-lb. steam to station header

The heat balance for the new unit is simple. The superposed cycle is separate from former equipment; feedwater is taken from the existing boiler-feed header and returned as steam to the low-pressure cycle. Two 10,000-kw. condensing turbines are bled to first-stage heaters for heating their own condensate and at a higher stage (about 10 lb.) for the city heating-system supply. The 10-lb. header also feeds an open heater used as a second-stage heater, into which condensate comes directly from the hotwell pumps of the two smaller condensing units, and at which point filtered and softened makeup is introduced. After passing through blowdown condenser, condensate goes to third-stage heater supplied with 100-lb. steam.

Since all the above equipment existed at the time of laying out the new unit, and the entire station condensate is heated to about 330 F, only one additional heater has been installed. This heater is supplied by 210-lb. exhaust from the high-pressure turbine.

After the 5,000-kw. turbine is in operation, approximately 50 million kilowatt-hours per year will be generated at Cedar Rapids by steam used for industrial and heating purposes.

PRINCIPAL EQUIPMENT

Iowa Electric Light & Power Co.——Cedar Rapids, Ia.

Boiler and waterwalls.....Springfield Boiler Co.
Boiler heating surface, 13,389 sq.ft.; waterwalls, 7,137 sq.ft.; max. continuous steaming cap., 300,000 lb. per hr.; working press., 675 lb. G.; total steam temp., 765 F; furnace volume, 7,500 cu.ft.; max. B.t.u. liberated per cu.ft. per hr., 34,000.
Superheater, 4,533 sq.ft.....The Superheater Co.
Economizer, 4,608 sq.ft.....Foster Wheeler Co.
Air heater, 20,500 sq.ft., Ljungstrom type.....Air Preheater Co.
Furnace refractories.....Bigelow Liptak Co.
Boiler heat insulation.....Bigelow Liptak Co.
Armor blocks on waterwalls, Hunter.....Springfield Boiler Co.
Steel ducts and breechings.....Iowa Steel & Iron Co.
Stack, steel—refractory lined.....Iowa Steel & Iron Co.

COMBUSTION EQUIPMENT:

Automatic combustion control.....Askania Regulator Co.
Soot blowers.....Diamond Power Specialty Co.
Stokers, one, underfeed-water-cooled; 14 retorts; projected grate area, 543 sq.ft.; air temp. 450 F.....American Equipment Co.
Stoker motors, two; 10 hp., 1,800 r.p.m.....General Electric Co.
Speed controls, two, variable-speed transmissions.....Link Belt Co.
Clinker grinder, piston drive.....American Engineering Co.
Forced-draft fan, one; cap., 90,000 c.f.m.; static pressure 13.8 in.; vane control.....B. F. Sturtevant Co.
Forced-draft-fan drive; 300-hp., 1,200-r.p.m., squirrel cage motor.....General Electric Co.
Induced-draft fan, one, Sirocco dust-collecting; cap. 160,000 c.f.m.; static press., 11.5 in.....American Blower Co.
Induced-draft-fan drive by 500-hp.; 600-r.p.m.; squirrel-cage motor.....General Electric Co.
Connection between fan and drive, hydraulic coupling.....American Blower Co.
Hydraulic coupling control, automatic.....Askania Regulator Co.

VALVES:

Safety valves.....Crosby Steam Gage & Valve Co.
Non-return valves on turbine exhaust lines...Edward Valve & Mfg. Co.
Stop and check valves in feed lines.....Edward Valve & Mfg. Co.
Blowdown valves.....Yarnall Waring Co.
High-pressure valves.....Crane Co.
Turbine safety valves.....Consolidated Ashcroft-Hancock Co.
Reducing valve and desuperheater.....Republic Flow Meters Co.
Atmospheric relief valves.....Swartwout Co.

PIPING TRAPS AND STRAINERS:

Pipe heat insulation.....Philip Carey Co.

FEEDWATER SYSTEM:

Water columns.....Yarnall-Waring Co.
Floor-level water columns.....Yarnall-Waring Co.
Feedwater regulators, three-element type.....Bailey Meter Co.
Boiler-feed pumps, two; cap., 665 g.p.m.; 1,730-ft. head.....Allis-Chalmers Co.
Feed-pump drive, one, 350-hp., 3,570-r.p.m., squirrel-cage motor and one 410-hp., 4,000-r.p.m. turbine.....Allis-Chalmers Co.
Feedwater heaters, closed type.....Foster Wheeler Co.

METERS:

Boiler meter.....Bailey Meter Co.
Steam flowmeters.....Bailey Meter Co.
Steam-pressure and temperature recorders.....Foxboro Co.
Feedwater flowmeter.....Bailey Meter Co.
Blowdown meter.....Bailey Meter Co.
Boiler water-level indicators.....Bailey Meter Co.
Temperature recorders.....Leeds & Northrup Co.
General temperature indicator.....General Electric Co.
Pyrometers.....Leeds & Northrup Co.
Draft gages, multiple point.....Hays Corp.

GENERATING UNIT:

One 5,000-kw., 3,600-r.p.m. turbine; throttle steam conditions, 650 lb., 750 F; pressure at exhaust 230 lb. abs.....General Electric Co.
Turbine connects directly to 7,175-kva., 0.70-p.f., 3-phase, 60-cycle, 14,000-volt generator.....General Electric Co.
Generator air cooler.....General Electric Co.
Air-cooler water pump.....Dayton Dowd Co.
Driven by 7.5-hp., 1,745-r.p.m. motor.....General Electric Co.
Oil cooler.....General Electric Co.
Station switchboard.....General Electric Co.
Station transformers.....General Electric Co.
Oil circuit breakers.....General Electric Co.

SPRINGDALE

Primarily to increase capacity inexpensively without adding to cooling - water requirements, Springdale adds a 50,000-kw. top, 1,270 lb.* and 935 F. Two-stage boiler furnace has many advantages

SPRINGDALE STATION, mine-mouth plant of West Penn Power Co., is 18 miles from Pittsburgh on the Allegheny River. Initially operated in 1920, it was designed to be the principal station of West Penn system. During recent years it has operated at capacity factors considerably higher than most other stations now installing tops. As a real "mine-mouth" plant, Springdale is almost unique among American stations. Its coal comes from a company-owned mine only a few hundred yards across the river from the station proper.

Scene of pioneering experiments with pulverized coal, Springdale reflects the whole history of furnace design from 1922 to the 2-stage furnace of 1937.

Link to Past Design

In 1936 Springdale had five turbines operating at 330 lb. and 650 to 725 F with a total net rated capacity of 180,000 kw. (192,000 kw. maximum net developed) and was part of a system having 373,855 kw. of installed capacity. Of the 14 boilers, 12 were stoker-fired and two fired by pulverized coal.

As with many other old plants, the situation at Springdale called for a top as the most economical way to add capacity. No additional boilers had been installed with the latest turbine unit, so maximum capacity of station turbines exceeded available boiler capacity. This was another factor favoring a top.

The three most modern turbines in the station were designed for a steam temperature of 672 F. It was found that high-pressure steam at 1,270 lb. and 935 F (superheater outlet) would give a h.p. turbine exhaust temperature of 626 F at full load. Exhausting directly into the header of l.p. boilers, and mixing with steam produced by them, would give a steam temperature high enough to avoid excessive moisture in the exhaust of the l.p. turbine.

Boiler Space

As the most economical way to make space for the new h.p. boilers and turbine six old boilers (5 stoker-fired and one pulverized coal-fired) were removed. The retained l.p. boilers have economizers. The new h.p. boilers, together with the remaining l.p. units, can supply enough steam to carry the maximum possible output of l.p. turbines under all normal conditions.

Present program (now nearing completion) includes one 50,000-kw. superposed turbine served by three steam-generating units, each able to deliver at present without the high-pressure crossover heater 450,000 lb. per hr. (continuous rating) at 1,270 lb. and 935 F (575,000 lb. maximum rating) when supplied with 335 F feedwater. Full-load steam demand of high-pressure turbine is 1,325,000 lb. per hr.

Heat Balance

Three of the low-pressure turbines bleed at three points, of which the lower two are used to heat condensate to 225 F and the third to supply the evaporators. Condensate at 225 F, evaporator steam and coil condensate, flash steam from the continuous high-pressure blowdown system, exhaust steam from the steam-driven auxiliaries of l.p. turbines, gland leakoff steam from h.p. turbine, and condensate from boiler-feed-pump exhaust heaters are all brought together into the three original deaerating heaters.

The boiler-feed pumps take water from these deaerators and supply water directly to the l.p. boilers and to the h.p. boiler-feed pumps. Between high- and low-pressure boiler-feed pumps are a set of boiler-feed pump exhaust heaters and heat exchangers for cooling heater drains. Three turbine drives for main boiler-feed pumps supply exhaust steam to exhaust heaters at 100 lb. G. A regulating valve on a separate supply line from the 325-lb. steam heater makes up steam deficiency at certain loads, to maintain constant feedwater temperature. Feedwater enters the h.p. boiler-feed pump at about 335 F, and then goes directly to economizer inlet.

Overload capacity of the h.p. boilers will be more economical than that of existing l.p. boilers. Therefore, the usual crossover heater using h.p. exhaust has been omitted for the present. This gives a lower feed temperature and a greater boiler heat output.

Steam-Generating Units

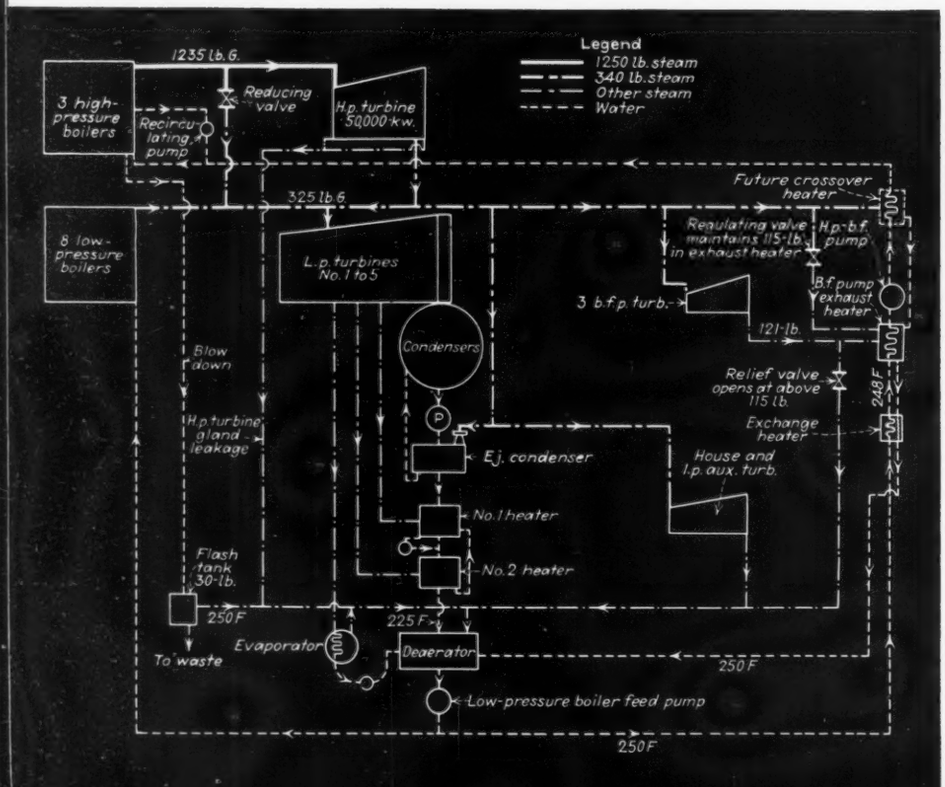
Three B.&W. single-drum, sectional header boilers are of single-pass design, with gas space divided into two sections for superheat control. Only 6,200 sq. ft. of the heating surface is in sectional-header tubes.

A water-cooled baffle divides the furnace into two sections. The first stage (primary combustion space) is walled with "stud tubes" to maintain high furnace temperature with resulting high combustion efficiency and free slag flow. Slag is continuously tapped. Second furnace stage is bare-block lined, giving a large amount of heat-absorbing surface. Furnace volume is 15,450 cu.ft.; heat liberation is high, 46,500 B.t.u. per cu.ft. Firing is by six intertube burners supplied by three pulverizers. The horizontal-tubular air heater has 32,630 sq.ft. of heating surface.

An innovation designed by West

* Note: These are the superheater outlet pressures specified in contract. Boiler drum pressure is 1,450 lb.

Flow diagram. Feature: Regulating valves maintain proper heater pressure and exhaust steam balance



Penn Power is a single-stage centrifugal pump which introduces highly concentrated water from boiler drum into economizer header. This helps eliminate tube difficulties. With suction at 1,260 lb. and 575 F, pump delivers about 60 g.p.m. at 15 lb. differential. It is direct-connected to a 3-phase, 3-hp. motor.

Each h.p. boiler is equipped with feedwater-level control. In addition, boiler feedwater is automatically checked a fixed amount above steam pressure.

Coal and Ash Handling

A tunnel brings coal directly into plant from company mine across the river. Ash and refuse from Cottrell eliminators are removed from water-sealed pits by clamshell and pumped to swamp or shipped by truck or railroad. Slag from the new boilers passes through openings in the water-tube screen separating primary and secondary furnaces, and falls 12 ft. to a pool of water from which it is removed by clamshell buckets.

Turbine

Single-cyl. impulse-reaction Westinghouse turbine, has one Curtis stage and nine rows of reaction blades. Blade path has a low ratio of perimeter to area at middle stages. This gives maximum insurance against capacity loss from scaling encountered in high-pressure installations, which is confined to a definite portion of the blade path between h.p. and l.p. stages.

Dimensions are notably small—only 10 ft. $\frac{5}{8}$ in. between bearing centers, and 9 ft. 9 in. high from floor to top of valve operating lever. The 2-piece turbine cylinder is cast of carbon-molybdenum steel. Shape and support are designed to minimize distortion. An annular belt of steam surrounds the entire cylinder at the high-pressure end to maintain equal temperature in base and cover.

The governor is of the oil-operated transformer type. An impeller mounted on turbine shaft discharges oil at a pressure varying as the square of the speed. Governor transformer magnifies small pressure changes and the magnified pressure actuates the relays of valve-operating mechanism.

This governor mechanism is so sensitive that a speed change of less than one r.p.m. will change steam flow in a period of less than one second from initial speed change to first movement of admission valve.

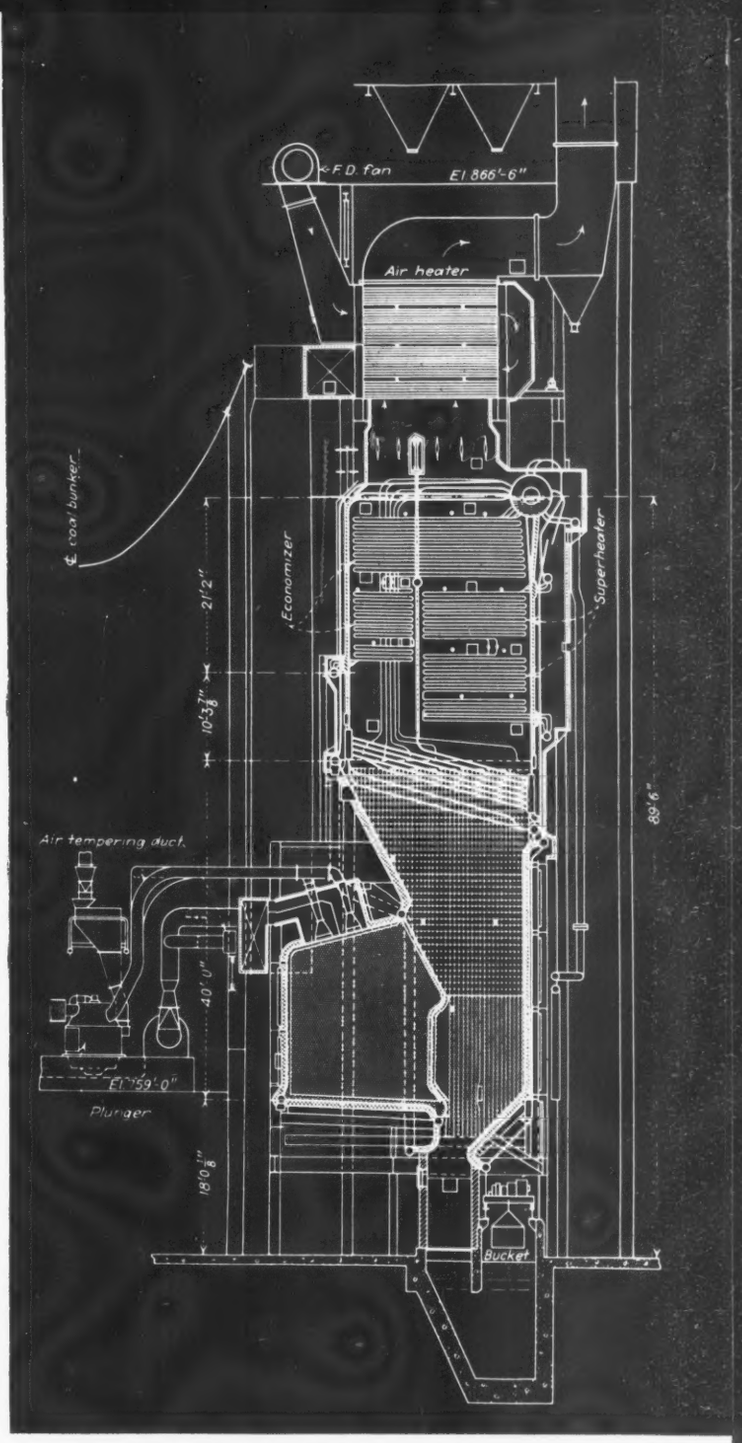
H.p. steam bypass around the h.p. turbine is designed to pass the output of each boiler to the l.p. system separately. There are 3 pressure-reducing valves and 3 spray-type desuperheaters. Desuperheaters and reducing valves are arranged for either full automatic or manual control.

Except for standby drives for boiler-feed pumps and exciters, motor drives have been almost exclusively used in the existing Springdale Station. However, the h.p. boiler-feed pumps will require large power and will therefore be driven normally by turbines to develop this power at low cost from steam later used for feed heating.

The heat balance of the existing l.p. turbines was satisfactory. Old equipment brought the feed temperature to 235 F, low enough to permit absorbing practically all exhaust of the h.p. pump turbine. Such an arrangement, however, would not be satisfactory if h.p. pumps worked at a small fraction of their capacity. Because of low efficiency at low rating, the feed-water heater would not absorb all of the exhaust. If an auxiliary motor drive were installed to make up any deficiency in available turbine power it would be necessary to operate at least one pump near synchronous speed, with a large increase in total power requirements.

It was finally decided to utilize boiler-feed pump turbines especially designed to give their best efficiency well below full load. This gives required power under all normal load conditions. To meet abnormal requirements power can be increased by reducing the exhaust pressure (by discharging some steam to the deaerators).

Inasmuch as the available low-cost power was completely utilized for boiler-feed pump drives, and as it was thought advisable to avoid long auxiliary steam lines, other boiler auxiliaries are motor driven. Both forced- and induced-draft fans are vane controlled and driven by constant-speed motors.



Steam-generating unit: 575,000 lb. per hr. max. capacity at 1,450 lb. and 935 F.

Valves and Piping

High-pressure steam piping is carbon-molybdenum steel, 0.1 to 0.2% carbon and 0.45% to 0.65% molybdenum. The 12-in. nominal pipe for main boiler and turbine leads has a minimum thickness of 1.294 in.

Although high-pressure water piping is designed for 2,100 lb. max. pressure, its temperature is limited to 450 F, so seamless carbon-steel pipe (carbon under 0.35%) is used.

Carbon-molybdenum steel was selected for h.p. steam piping because

of its low creep value and machining and welding qualities. Wherever possible, welded joints have been used for all h.p. steam and water piping. All welds for pipes larger than 2½ in. have been electrically treated to relieve internal stresses.

Valves

Valve bodies for h.p. steam are carbon-molybdenum steel. Seats and disks of main steam gate valves are of nitrided stainless steel. The non-return, boiler-feed and pressure-reducing valves are fitted with seats and disks of carbon-molybdenum steel with contacting surfaces of Stellite. Seats are screwed in and seal welded to the valve body.

Welds in pipe joints were subjected to a hydrostatic test of twice the working pressure, and hammer tested at that pressure by an inspector of the Hartford Steam Boiler Inspection & Insurance Co.

Electrical Equipment

The new generator will be a 50,000-kw., unity power factor, 11,500-volt, 3-phase, 60-cycle, 3,600-r.p.m., hydrogen-cooled unit.

No new feeders will be added to the present 132-kv. and 25-kv. from Springdale Station. Interrupting capacity of the present 11- and 132-kv. oil circuit breakers will be increased by installing Deion contacts. The new 50,000-kw. generator will be connected to the 11.5-kv. bus and to its own 60,000-kva., 11.5/132-kv. step-up transformer bank, which, in turn, will be connected to the present 132-kv. bus. A brick wall is built between transformers to minimize fire hazard. The transformer bank will consist of three 20,000-kva., 11,500 132,000 volts, 13% reactance transformers.

All the new switching equipment for 11.5 kv. will be metal clad. The 2,300-v. concrete switching cell structure for No. 1 and No. 2 units auxiliaries will be replaced by high-capacity lift-up type switchgear cubicles.

Performance and Economics

With h.p. boilers only operating, the net heat rate of the Springdale plant will be 12,100 B.t.u. At maximum load, with l.p. boilers also operating, it will be 13,800 B.t.u.

PRINCIPAL POWER-PLANT EQUIPMENT

No. 6 Unit High-Pressure Extension, West Penn Power Co., Springdale, Pa.

Consulting Engineers ..... Sanderson & Porter
Boilers and waterwalls ..... Babcock & Wilcox Co.
Boilers, 3; heating surface per boiler 6,200 sq.ft.; waterwalls 4,880 sq.ft.; max. continuous steaming cap., 575,000 lb. per hr.; working press. 1,450 lb.G.; total steam temp., 935 F; furnace volume, 15,450 cu.ft.; max. B.t.u. liberated per cu.ft. per hr., 46,500
Superheater ..... Babcock & Wilcox Co.
Economizer, 22,430 sq.ft. ..... Babcock & Wilcox Co.
Steam washer, cap. 575,000 lb. per hr ..... Babcock & Wilcox Co.
Air heater, 32,630 sq.ft. ..... Babcock & Wilcox Co.
Boiler and furnace settings ..... Babcock & Wilcox Co.
Boiler heat insulation ..... Babcock & Wilcox Co.
Armor blocks on water walls ..... Babcock & Wilcox Co.
Boiler ducts and breechings ..... Babcock & Wilcox Co.
Stack ..... (Present stack formerly used for low-press. boilers)

COMBUSTION EQUIPMENT:
Automatic combustion control ..... Hagan Corp.
Soot blowers ..... Diamond Power Specialty Co.
Pulverized-coal burners, 6 per boiler; cap. each, 9,150 lb. per hr. ..... Babcock & Wilcox Co.
Coal pulverizers, 3; ball type; cap. each, 18,300 lb. per hr. Babcock & Wilcox Co.
Pulverizer-driving motor, constant speed, high torque, 125 hp., 1,200 r.p.m., 2,300 volts ..... Westinghouse Elec. & Mfg. Co.
Driving equipment, multi V-belt ..... Worthington Pump & Mch. Corp.
Pulverizer-motor control ..... Assembled unit—own design
Mill blowers, 3 per boiler ..... Babcock & Wilcox Co.
Mill-blower driving motor, constant speed, normal torque, 60 hp., 1,800 r.p.m., 2,300 volts ..... Westinghouse Elec. & Mfg. Co.
Mill-blower-motor control ..... Assembled unit—own design
Coal feeders per boiler, 3; rotating-table type .. Babcock & Wilcox Co.
Coal-feeder driving motor, constant speed, normal torque, 1 hp., 1,800 r.p.m., 440 volts ..... Westinghouse Elec. & Mfg. Co.
Oil-ignition torch ..... Babcock & Wilcox Co.
Forced-draft fans, 2 per boiler; cap. each, 86,000 c.f.m.; static press. 12 in.; vane control ..... B. F. Sturtevant Co.
Forced-draft-fan drive, 500-hp., 1,780-r.p.m., squirrel-cage, open, self-ventilated motor drives 2 fans .. Westinghouse Elec. & Mfg. Co.
Flexible coupling between fan and drive ..... Bartlett-Hayward Co.
Induced-draft fans, 2 per boiler; cap. each, 83,000 c.f.m.; static press. 16 in. vane control ..... B. F. Sturtevant Co.
Induced-draft-fan drive, 700-hp., 1,175-r.p.m., squirrel-cage, open, self-ventilated, 2,300-volt motor Westinghouse Elec. & Mfg. Co.
Flexible coupling between fan and drive ..... Bartlett-Hayward Co.

COAL-HANDLING EQUIPMENT:
Coal handling, belt conveyor ..... Heyle Patterson Co.
Coal-handling-equipment motors and controllers General Electric Co. and Westinghouse Elec. & Mfg. Co.
Coal crusher, ring mill ..... American Engineering Co.
Coal-crusher driving motor, wound rotor, 175 hp. General Electric Co.
Coupling on crusher motor ..... Poole Eng. & Mach. Co.
Crusher-motor control ..... General Electric Co.
Magnetic separator ..... Ohio Electric Mfg. Co.
Coal scales ..... Richardson Scale Co.

ASH-HANDLING EQUIPMENT:
Ash-handling equipment on furnace ..... Allen-Sherman Hoff Co.
Ash and soot precipitator ..... Research Corp.

VALVES:
Safety valves, 5 per boiler ..... Consolidated Ashcroft Hancock Co.
Blowdown valves, 2 per boiler ..... Babcock & Wilcox Co.
Non-return valves ..... Edwards Valve & Mfg. Co.
Stop and check valves in feed lines Chapman Valve Mfg. Co., and Edward Valve & Mfg. Co.
High-pressure valves ..... Chapman Valve Mfg. Co.
Medium-pressure valves ..... Pratt & Cady Co.
Low-pressure valves ..... Pratt & Cady Co.
Desuperheater reducing valves and control .. Republic Flow Meters Co.
Atmospheric relief valves ..... Atwood & Morrill Co.
Electric valve operators, Limitorque ..... Philadelphia Gear Works

PIPING, TRAPS AND STRAINERS:
Piping contractor ..... Pittsburgh Piping & Equipt. Co.
Pipe heat insulation ..... Johns Manville Co.

FEEDWATER SYSTEM:
Water columns ..... Diamond Power Specialty Corp.
Floor-level water columns ..... Diamond Power Specialty Corp.
Feedwater regulators ..... Republic Flow Meters Co.
Boiler feed pumps, 4; cap. each, 1,554 g.p.m.; 3,600 ft. head Ingersoll-Rand Co.
Feed-pump drive, 2 turbine; 1,900-hp. each; 1 motor, 1,750-hp., 3,575 r.p.m.; 1 dual, 1,900-hp. (turbine) 1,7500-hp. (motor) Westinghouse Elec. & Mfg. Co.
Feed-pump-motor controllers ..... Republic Flow Meters Co.
Feed-pump speed-regulating valves .... Westinghouse Elec. & Mfg. Co.
Feed-pump governors ..... Westinghouse Elec. & Mfg. Co.
Feedwater heaters ..... Westinghouse Elec. & Mfg. Co.
Feedwater heater drainage regulator ..... Cochrane Corp.
Continuous-blowdown equipment ..... Babcock & Wilcox Co.
Feedwater treatment, present system used ..... Hall Laboratories

METERS:
Boiler meter and control board ..... Hagan Corp.
Turbine and heater control panels ..... Republic Flow Meters Co.
Boiler meters ..... Bailey Meter Co.
Steam flowmeters .... Bailey Meter Co. and Republic Flow Meters Co.
Air flowmeters ..... Bailey Meter Co.
Steam flow, pressure and temp. recorders Bailey Meter Co. and Republic Flow Meters Co.
Feedwater flowmeters ..... Republic Flow Meters Co.
Boiler water-level indicators ..... Diamond Power Specialty Corp.
Boiler water-level recorders ..... Bailey Meter Co.
Boiler-load indicators ..... Hagan Corp.
Water-pressure gages, indicating .. Consolidated Ashcroft Hancock Co.
Turbine-pressure gages, indicating .... Westinghouse Elec. & Mfg. Co.
Turbine-pressure gages, recording ..... Republic Flow Meters Co.
Turbine speed indicators, vibrating reed .. Westinghouse Elec. & Mfg. Co.
Thermometers, industrial ..... Taylor Instrument Companies
Temperature recorders .. Bailey Meter Co. and Republic Flow Meters Co.
Generator temperature recorder ..... Leeds & Northrup Co.
Draft gages, multiple point ..... Bailey Meter Co.
CO_2 recorder ..... Hays Corp.

GENERATING UNIT:
One, 50,000-kw., 3,600-r.p.m. turbine; throttle steam conditions, 1,235 lb.G., 925 F; exhaust pressure 355 lb. abs. Westinghouse Elec. & Mfg. Co.
Turbine connects directly to 50,000-k.v.a., 1.00-p.f., 3-phase, 60-cycle, 11,500-volt generator .... Westinghouse Elec. & Mfg. Co.
Desuperheater on turbine exhaust ..... Elliott Co.
Automatic desuperheater control ..... Bailey Meter Co.
Generator hydrogen cooler ..... Westinghouse Elec. & Mfg. Co.
Oil cooler ..... Westinghouse Elec. & Mfg. Co.
Exciter, direct connected ..... Westinghouse Elec. & Mfg. Co.
Station switchboard, assembled unit .... Westinghouse Elec. & Mfg. Co.
Automatic voltage regulator ..... Westinghouse Elec. & Mfg. Co.
Station transformers ..... Westinghouse Elec. & Mfg. Co.
Oil circuit breakers ..... Westinghouse Elec. & Mfg. Co.
Electric elevators ..... Westinghouse Elec. & Mfg. Co.
Travelling crane ..... Whiting Corp.

WEADOCK

New plant. Two 400,000-lb.-per-hr. boilers. Two 35,000-kw., 3600-r.p.m. turbines. Boiler design conditions: 900 lb. gage and 900 F max. Features: pulverized coal (dry bottom); no steam-driven auxiliaries; 2-stage dust separation. A simple, dependable, low-cost design which will produce a net kilowatt-hour for 12,040 B.t.u. at full load and 29 in. vacuum

JOHN C. WEADOCK station, near Bay City, Mich., on the right bank of and at the mouth of Saginaw River (Lake Huron), is a completely new plant, under construction for the Consumers Power Company. Scheduled to start in 1938 to meet rapidly growing load of the system, in a sense Weadock station is a "standardized' plant, because identical heat balance and plant design (except for size of units) will be used in the new installations at the following plants of the Consumers Power Company and other subsidiary companies of Commonwealth & Southern Corp.:

Bryce E. Morrow (35,000-kw. turbine) Consumers Power Co.; New Castle (35,000-kw. turbine), Penn. Power Co.; East Peoria (25,000-kw. turbine), Cent. Ill. Light Co.; Ohio River (20,000-kw. turbine), So. Ind. Gas & Elec. Co.; Mad River (20,000-kw. turbine), Ohio Edison Co.

Initial installation will consist of two 35,000-kw., 3,600-r.p.m., tandem-compound turbines served by two 400,000-lb.-per-hr. steam-generating units, pulverized-coal fired and equipped with waterwalls, economizer, air heater and dust collector. Boiler and superheater design conditions are 900 lb. G and 900 F maximum, with average operating conditions somewhat lower. Throttle conditions in actual operation will vary with load, averaging about 800 lb. G and 850 F.

Background of Design

Following local conditions and engineering policies were primary factors in determining size and number of units, steam conditions, hookup and general design: Largest units on connected system are 35,000 kw., so new plant should have no larger units to avoid dropping more than 35,000-kw. capacity in case of a turbine shutdown. Load growth called for an initial installation of about 70,000 kw. at this site, hence two turbines. One boiler per turbine gave lowest investment cost with adequate reliability.

Fuel commercially available in the locality is high-grade, long-haul, high-cost bituminous from Eastern Kentucky and West Virginia, averaging about 13,500 B.t.u. per lb. as fired and with ash-fusion temperature of about 2,600 F. With pulverized-coal firing and available coal, dry-bottom operation was selected as satisfactory. The low heat-release rate of 24,500 B.t.u. maximum was selected to avoid slagging troubles, as the boiler must be capable of sustained maximum outputs.

With high-cost fuel, efficiency was desired, but with moderate first cost, simplicity and maximum reliability.

Consideration was given to higher design pressures and temperatures. With 1,200-lb. throttle pressure, a temperature of 1,000 F was indicated, but with present materials it was not considered advisable to exceed 925 F. With this limitation the gain in efficiency over selected design pressure and temperature was not attractive.

Heat Balance

The turbine (see flow diagram) is bled at 5 points, but only the lower four are normally used. Bleed No. 2 feeds steams at 152 lb. abs. (full turbine load) to the evaporator, which, in turn, delivers its vapor at 53 lb. abs. to the H.P. heater. Valve on No. 1 bleed is normally closed, but may be opened to supply steam at 262 lb. abs. for cracking scale, also (in emergency) to increase the temperature differential and hence the evaporator capacity.

Feedwater enters L.P. heater at 82 F, I.P. heater at 153 F, H.P. heater at 220 F, and economizer at 278 F. No. 3 bleed is at the same pressure as the evaporator vapor, and is fed with it to the H.P. heater. No. 4 bleed goes to I.P. heater at 22 lb. abs. No. 5 bleed to L.P. heater at 5.3 lb. abs. Heater drips are cascaded, as usual, and low-pressure heater drains are normally pumped back into the feed line from the low-pressure heater.

A thermostatically controlled bypass (not shown) around I.P. heater bypasses just enough of the flow at maximum loads to keep I.P. heater exit-water temperature at 220 F maximum, so that water will not boil in elevated surge tank. At full turbine load feedwater enters economizer at 278 F and goes to boiler at 440 F.

Steam-Generating Units

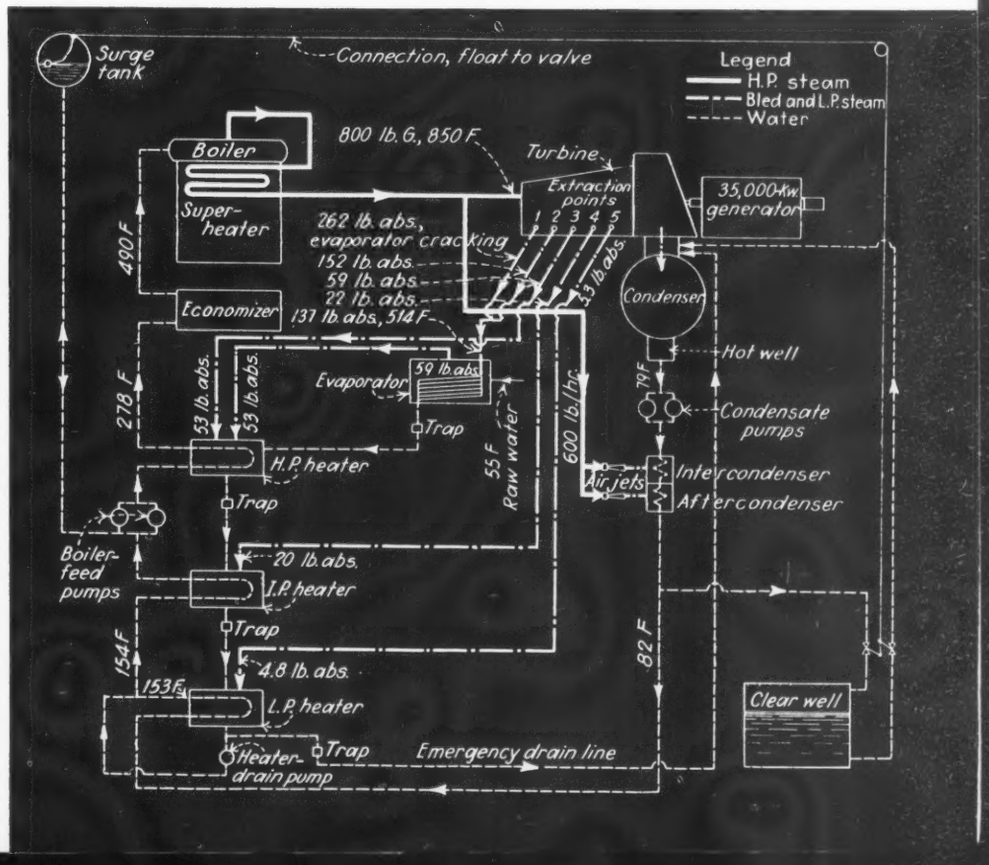
The two 400,000 lb.-per-hr. (max. continuous) Foster Wheeler steam-generating units, with economizer and air heater, have heating surface (each) divided as follows:

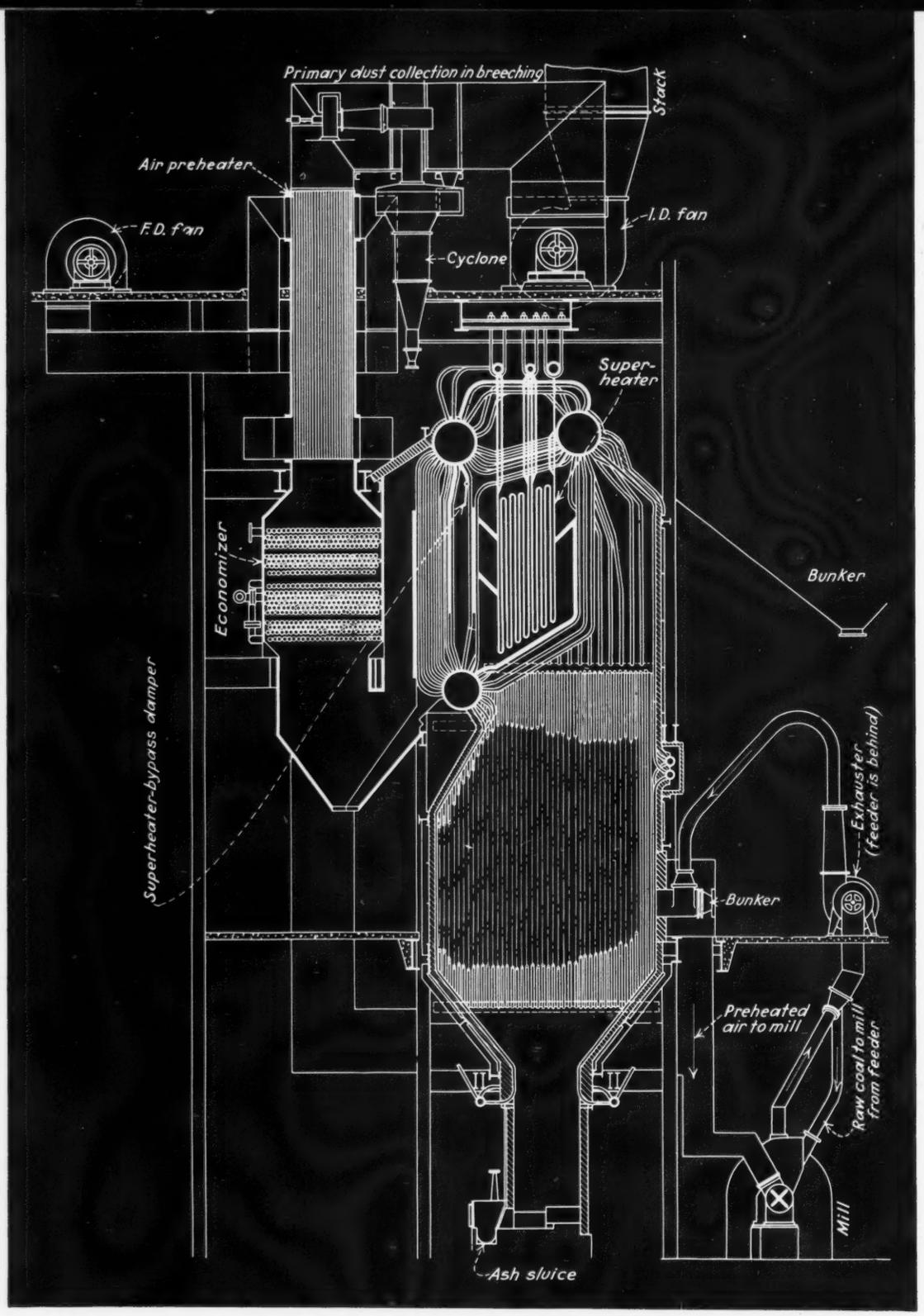
Boiler	7,400 sq. ft.
Waterwalls	4,100 sq. ft.
Superheater	9,500 sq. ft.
Economizer	28,500 sq. ft.
Air heater	54,100 sq. ft.

Waterwall risers all discharge to boiler drums. Note that double headers are used in front waterwalls to accommodate close-spaced waterwall tubes (3-in. O.D. seamless spaced on 3¼-in. centers).

Superheater hangs straight down in a space completely free of boiler tubes. This simplifies support, minimizes tube slagging, provides accessibility of both boiler and superheater tubes. Three rows of boiler tubes, spaced on 13-in. centers, precede the superheater, acting as slag screens. This same 13-

Flow diagram. Features: Evaporator discharges to H.P. heater. No deaerator. Discharge of I.P. heater is thermostatically controlled to 220 F





Steam-generating Units: 400,000 lb. per hr. max. capacity each at max. design conditions of 900 lb. and 900 F (operating somewhat lower)

in. spacing is used throughout the boiler to increase tube-ligament percentage and thus permit thinner and therefore cheaper drums. The all-welded drums are (upper two) 48 in. x 32 ft. 3 in., tube plates $2\frac{3}{8}$ in. thick, wrapper plates $1\frac{27}{32}$ in., and the heads $2\frac{1}{8}$ in.

Soot-blower nozzles for the upper part of superheater are spaced to correspond to boiler-tube spacing and the elements are set 2 ft. back from the superheater so that the same elements in this location can serve both boiler tubes and superheater tubes.

The economizer is of steel-tube design with cast-iron extended surface and is arranged for straight upflow of gases. Starting at top, water flows down through upper section, then out and in again at bottom and up through lower section. Thus any steam formed in starting up will easily pass to boiler drum, avoiding water hammer. (Feedwater regulator is ahead of economizer.)

Air heater, designed for extreme simplicity, is merely a vertical bank of straight tubes without baffles. Gas flows up through tubes, air down around them.

At 35,000-kw. turbine load (about 300,000 lb.-per-hr. on boiler) gas enters preheater at 435 F, leaves at 275 F. Air is heated from 100 F to 340 F.

Furnace is water-cooled on all sides and on hopper bottom, with fairly wide opening at bottom for discharge

of ash and with sides sloping 50 deg. from horizontal. Wall tubes are bare without fins, 3-in. seamless tubes on 3¼-in. centers. Furnace volume is 21,950 cu. ft. and maximum heat release 24,500 B.t.u. per cu. ft. per hr.

Unit system of firing is employed and coal is pulverized by ball mills (loose balls in horizontal rotating cylinder), two per boiler. With the primary air, pulverized coal is carried up through exhauster fans (2 per boiler) and delivered to 4 burners (2 per mill) of the turbulent, horizontal, circular type.

Coal and Ash Handling

Self-unloading Great Lakes coal ships will lay the fuel down in windrows along the new coal dock. Gantry crane transfers it to belt which carries it to transfer point where it can be crushed (if "run of mine"). From transfer point it goes by inclined belt to station bunkers; then to feeders and mills, as already described.

Ash is jetted to ash sluice which carries it to sump from which it is pumped to yard for fill.

Flue gas is cleaned dry by centrifugal separation in two stages. Primary separation is in a nest of 147 tubes filling the full section of the breeching. Inner tubes, surrounded by spiral strips, give gas a whirling motion in the annuler spaces and separate most of the dust at the ends of the tubes. Clean gas goes to stack, but a fraction, heavily laden with dust, passes to cyclone separators (2 per boiler) for final cleaning.

The two G.E. 35,000-kw., tandem-compound turbine-generators are identical. Speed is 3,600 r.p.m. Exhaust from H.P. cylinder goes through two overhead connections to the center of the double-flow L.P. cylinder. Exhaust hood is of steel-plate construction welded to condenser. Condenser shell is of welded-steel-plate construction with cast-iron waterboxes bolted on.

Each generator is hydrogen cooled, 43,750 kva., 3 phase, 60 cycle, 14,400 volts.

As already indicated, there are three heaters (L.P., I.P. and H.P.) and one evaporator for each unit. Heaters are of surface type. Evaporator is high-pressure type with tubes slightly bowed for expansion and drainage. The plant has no deaerator, air being removed in the condenser hotwell and by venting of heaters.

Fans and Pumps

All auxiliaries are motor driven. There is not even a steam-driven feed pump. Studies of the engineers showed that heat storage of the furnace is insufficient to cause trouble from feed failure, providing firing is stopped immediately. Main auxiliary drives are by induction motors.

Each boiler has one forced-draft fan with straight blades, sloping back. The unit delivers 130,000 c.f.m. of 100-F air at 11.8-in. static pressure. Speed is 1,123 r.p.m., shaft power 322 hp. Corresponding figures for the I.D. fan (one per boiler) are: 215,000 c.f.m., 300 F, 14.0 in. static press., 850 r.p.m., 691 hp. Blades are curved forward. Both I.D. and F.D. fans are connected to motors by variable-speed hydraulic couplings.

2,300-volt motors are used for large auxiliaries and 440-volt for small, the dividing line being about 100 hp.

In addition to a full equipment of spring-loaded pop safety valves for the full capacity of each boiler, a special electrically operated safety valve is provided. This is set to blow before the spring-loaded valves, saving the latter from costly wear. Gate valve between it and superheater permits electrical valve to be removed for repair.

Valves and piping for H.P. steam are of carbon-molybdenum steel, all welded, including valve connections. In other piping (including H.P. feed lines) shop welds are used where convenient, but these valves are flanged.

The two boilers are served by one concrete chimney, 275 ft. high above base and 17-ft. internal diameter at top.

Plant capacity in future can be enlarged by removing end wall.

A three-winding transformer bank for each machine steps up 14,400 generator voltage to 22,000 for local use and to 140,000 volts for bulk delivery to interconnected system. All main load-switching equipment and transformers except generator switch are outdoors.

PRINCIPAL EQUIPMENT IN JOHN C. WEADOCK PLANT

Consumers Power Company, Bay City, Mich.

Engineers and builders.....Commonwealth & Southern Corp.
Boilers and waterwalls.....Foster Wheeler Corp.
Boilers, 2; heating surface each, 7,400 sq. ft.; waterwalls each 4,100 sq. ft.; max. continuous steaming cap. each, 400,000 lb. per hr.; max. working press. 900 lb. G; total max. steam temp. 900 F; furnace volume each, 22,000 cu. ft.; max. B.t.u. liberated per cu. ft. per hr. each, 24,500.
Superheater, 9,500 sq. ft.....Foster Wheeler Corp.
Economizer, 28,500 sq. ft.....Foster Wheeler Corp.
Steam washer, cap. each, 400,000 lb. per hr.....Foster Wheeler Corp.
Air heater, 54,100 sq. ft.....Foster Wheeler Corp.
Boiler and furnace settings.....Bigelow-Liptak Corp.
Stack, concrete type.....General Concrete Construction Corp.

COMBUSTION EQUIPMENT:
Soot blowers .....Diamond Power Specialty Corp.
Pulverized-coal burners, 4 per boiler; cap. each, 11,200 lb. per hr.....Foster Wheeler Corp.
Coal pulverizers, 2 per boiler; cap. each, 25,000 lb. per hr.....Foster Wheeler Corp.
Pulverizer-driving motor, 250 hp., 360 r.p.m., 2,300 volts, squirrel-cage .....Elliott Co.
Mill exhauster, 1 per pulverizer.....Foster Wheeler Corp.
Mill-exhauster driving motor, 75 hp., squirrel-cage.....Elliott Co.
Coal feeders, 1 per pulverizer, rotating-table type.....Foster Wheeler Corp.
Forced-draft fans, 1 per boiler; cap. 130,000 c.f.m.; static pressure 11.8 in. .....Clarage Fan Co.
Forced-draft-fan drive; 350-hp., 1,200-r.p.m., 2,300-volt, squirrel-cage motor .....Elliott Co.
Connection between fan and drive, hydraulic coupling.....American Blower Corp.
Induced-draft fans, 1 per boiler; cap. 215,000 c.f.m.; static pressure 14.0 in.....Clarage Fan Co.
Induced-draft-fan drive, 700-hp., 900-r.p.m., 2,300-volt, squirrel-cage motor .....Elliott Co.
Connection between fan and drive, hydraulic coupling..... American Blower Co.

COAL-HANDLING EQUIPMENT:
Storage-yard gantry crane.....Industrial Brownhoist Corp.
Coal gates .....Henry Pratt Co.

ASH-HANDLING EQUIPMENT:
Ash-handling equipment on furnace, hopper and sluicing type.....Hydro Ash Corp.
Ash and soot precipitator.....American Blower Corp.

VALVES:
Safety valves.....Consolidated Ashcroft Hancock Co.
Blowdown valves.....Edwards Valve & Mfg. Co.
Non-return valves.....Lunkenheimer Co.
Non-return valves on turbine bleed lines.....Atwood & Morrill Co.
Stop and check valves in feed lines.....Lunkenheimer Co. & Chapman Valve Mfg. Co.
High-pressure valves .....Lunkenheimer Co.

FEEDWATER SYSTEM:
Water columns .....Diamond Power Specialty Corp.
Boiler-feed pumps, 3; cap. each, 1,000 g.p.m., 1,000-ft. head.....Worthington Pump & Mach. Corp.
Feed-pump drive, 800-hp., 3,600-r.p.m., squirrel-cage motor...Elliott Co.
Makeup-water pumps, 2; cap. each, 35 g.p.m.....American Steam Pump Co.
Makeup-water-pump drive, motor.....Howell Electric Motors Co.
Feedwater heaters .....Griscom-Russell Co.
Heater condensate pumps, 2; cap. each, 220 g.p.m.; 143-ft. head.....Allis-Chalmers Mfg. Co.

GENERATING UNITS:
Two, 35,000-kw., 3,600-r.p.m. steam turbines; throttle steam conditions 800 lb. G, 850 F; automatic bleed at 137, 44, 7, —10 lb. G; exhaust at 0.63 lb. abs.....General Electric Co.
Turbine connects directly to 43,750-k.v.a.; 0.80-p.f.; 3-phase, 60-cycle, 14,400-volt generator .....General Electric Co.
Generator hydrogen cooler.....General Electric Co.
Oil cooler .....General Electric Co.
Condensers, 33,000 sq. ft.....Foster Wheeler Corp.
Deaerating hotwell .....Foster Wheeler Corp.
Circulating pumps, 4; cap. total per condenser, 21,900 g.p.m.....Foster Wheeler Corp.
Circulating-pump drive: 200-hp., 400-r.p.m., 2,300-volt, squirrel-cage motor .....Elliott Co.
Condensate pumps, 4; cap. each, 850 g.p.m.....Foster Wheeler Corp.
Condensate-pump-driving motor, 60 hp., 1,200 r.p.m., 440 volts, squirrel cage .....General Electric Co.
Vacuum-jet pump, steam .....Foster Wheeler Corp.
House service pumps.....American Steam Pump Co.
Air compressors .....Ingersoll Rand Co.
Station transformers .....General Electric Co.

WEST END

Special boilers with furnace at side developed to suit existing low-headroom boiler house. Desuperheater can bypass entire turbine steam flow within ½ sec. Station capacity increased from 144,000 to 179,000 kw.

WEST END station of the Cincinnati Gas and Electric Company, on the Ohio River at Cincinnati, is particularly well adapted for installation of a topping unit. In the Ohio River flood zone, West End turbine-room floor is many feet above normal river level, requiring costly foundations for condensing units, an expense avoided by superposition. Preliminary study showed top at West End better than condensing unit at Columbia or new station.

Original installation in 1918 at 250 lb., 600 F, was two 25,000-kw. General Electric turbines. In 1920-21 two more similar units were added and remainder of 14 boilers of 120,000 lb. per. hr. capacity each were installed. All four turbines were rebuilt in 1929, their diaphragm nozzles changed and new generators installed and re-rated at 36,000-kw. each. Provision was also made for one stage of feedwater heating from a bleed point at the 13th stage of each turbine. Top increases station capacity from 144,000 to 179,000 kw.

Four of the 250-lb. boilers have been removed in two steps, making space for the three new high-pressure steam-generating units and the topping turbine within the existing boiler-house structure. Two of the old boilers were first removed, one of the steam generators completed and placed in operation. Then two more old boilers were removed, and two more new ones are in process of construction. These steps were necessary to maintain sufficient boiler capacity in the plant. High-pressure steam generated is now being used for every-week-day operation of low-pressure turbines through the desuperheater and reducing valve; top turbine will operate soon.

Steam-Generating Units

Existing boiler-house structure limited boiler height; about 47-ft. over-all was available. Large-capacity boilers first proposed required 80-ft. height and expensive building alterations; open-pass design finally developed fitted within building; capacity matched low-pressure turbine.

Three 350,000-lb.-per-hr., Babcock & Wilcox boilers, 1,450-lb., 910 F. are especially designed for low head-room with furnace combustion space alongside heat-absorbing surface rather than below it as in usual practice. Furnace is separated from superheater and economizer by three waterwalls of partial stud construction arranged as screen baffles to force the products of combustion through a complete upward and downward travel before admission to the superheater and economizer. Tendency to slag will occur in screen passes rather than in the superheater. Furnace is full stud waterwall construction on all six sides. Design was favored to provide some equipment capable of handling low-fusion-ash coal available to the plant.

Practically all evaporation of water is carried out in the waterwalls; what might be called boiler surface (drums and boiler tubes) is out of hot zone and acts as circulator system for supply to waterwalls. Superheat control is effected by dampers which operate to increase or decrease flow of gas past the superheater by means of a bypass economizer section. Economizer is sinuous-tube construction. Air preheater, tubular type, is vertically disposed above boiler.

Forced-draft fans are vane-controlled, driven by a constant-speed motor. Induced-draft fans, also constant speed, are damper controlled.

Coal handling for existing plant, stoker fired, was from storage yard or railroad cars to pit in the center of the boiler room and then to stoker hoppers by overhead crane with clamshell bucket. Now, new belt conveyor takes coal from storage to bunker. Weigh scales are included in downcomer from bunker to mills. Two B. & W. Type B mills supply four burners for each boiler unit system.

Furnace is continuous slag-tap; slag and flyash from dry bottom under superheater fall into water tank from which they are sluiced to settling basin. Settling basin is part of what was coal-storage pit. Clamshell bucket once used for coal handling to hoppers will load ash on cars.

Because the plant is within a mile of Cincinnati's business section, the added expense of a Cottrell precipitator was felt warranted by reduced stack emission.

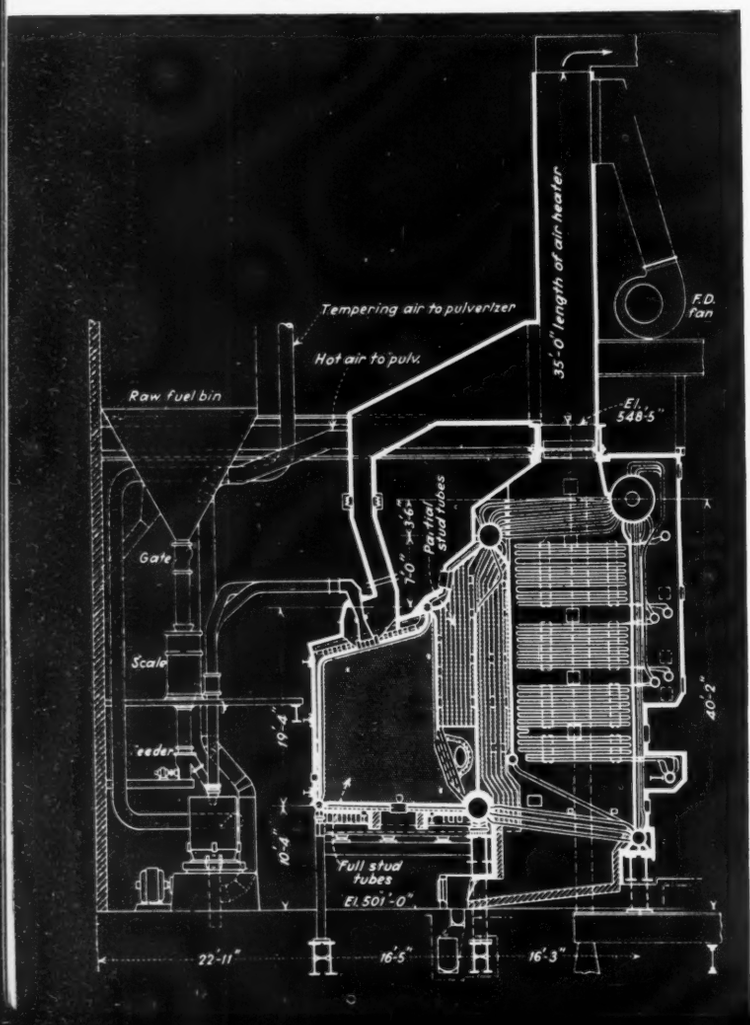
Turbine

Westinghouse turbine, 35,000-kw. at 3,600 r.p.m. is designed for 1,200-lb., 900-F steam conditions and exhausts sufficient steam at 250-lb., 600-F to supply two existing 36,000-kw. low-pressure units. Full hydraulic governor controls backpressure at predetermined maximum as well as the usual speed-responsive element. Westinghouse bar-lift arrangement of control valves is employed and throttle valve is of inverted type.

Generator is hydrogen cooled, with fin-tube coolers inside the housing. Oil seals prevent hydrogen loss, and automatic controls maintain slight positive hydrogen pressure.

Boiler-feed pumps, driven by bleeder turbines, provide exhaust steam at about 10-lb. G for 2nd-stage heaters and bleed steam at 30-lb. G for third-stage heaters. Existing first-stage heaters are supplied from bleed points on the condensing turbines. The makeup evaporator is supplied

Steam-generating unit: 350,000-lb.-per-hr. max. capacity at 1,450 lb. and 910 F



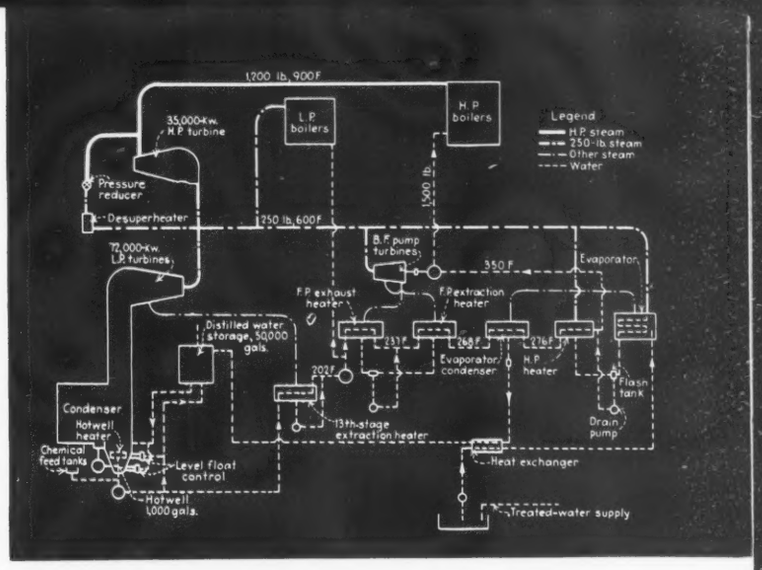
by 250-lb. steam and the evaporator condenser is located between the third- and fourth-stage heaters. Fourth-stage heater receives 250-lb. steam and heats feedwater to 350-F. Feed pumping is in two steps. No heaters follow the H.P. pump, so none need be built to withstand boiler pressure on the water side.

Piping and Valves

High-pressure steam piping is carbon-molybdenum steel and joints are welded by Pittsburgh Piping & Equipment Company. No field X-ray examination is made. High-pressure valves are 1,500-lb. series, cast carbon-molybdenum steel.

Since the high-pressure turbine is a major source of steam for the low-pressure system, protection for low-pressure turbines is supplied by a high-capacity, quick-action desuperheater station. Two valves are used in series, a regulating valve constantly controlled to pass the same amount of steam as instantaneously is being used by the high-pressure turbine, and a second quick-opening valve, which normally acts as a shut-off, but when opened, brings the regulating valve into operation within ½-sec. The spray-type desuperheater is designed so that no valves or parts have to move to cause water to flow to the nozzle, but instead the pressure drop created by the flow of steam through the desuperheater venturi is utilized.

Generator is wound for 13,200-volt bus potential. New section of switchhouse building has been completed to provide additional capacity. New high line is also under construction for interconnection with Columbia Station of the same company farther down the Ohio River. Added condensing capacity is projected for Columbia, the two installations providing reinforcement at needed points and increased system reliability.



Flow diagram. Feature: Boiler-feed-pump turbine bled to supply intermediate-pressure heater; exhausts to low-pressure heater

PRINCIPAL EQUIPMENT IN WEST END STATION

Cincinnati Gas & Elec. Co., Cincinnati, O.

Consulting Engineers	Sargent & Lundy
Boilers and waterwalls	Babcock & Wilcox Co.
Boilers, 3; heating surface including waterwalls, 7,200 sq.ft.; max. continuous steaming cap. each, 350,000 lb. per hr.; working press., 1,450 lb. G; total steam temp., 910 F; furnace volume each, 4,800 cu.ft.; max. B.t.u. liberated per cu.ft. per hr. each, 56,000.	
Superheater, 7,357 sq.ft.	Babcock & Wilcox Co.
Economizer, 15,000 sq.ft.	Babcock & Wilcox Co.
Steam washer	Babcock & Wilcox Co.
Air heater, 34,800 sq.ft.	Babcock & Wilcox Co.
Boiler and furnace settings	Babcock & Wilcox Co.
Furnace refractories	Babcock & Wilcox Co.
Boiler heat insulation	Babcock & Wilcox Co.
Armor blocks on waterwalls	Babcock & Wilcox Co.
Boiler ducts and breechings	Young & Beitke Co.
Structural-steel contractor	Babcock & Wilcox Co.

COMBUSTION EQUIPMENT:

Automatic combustion control	Republic Flow Meters Co.
Combustion-control oil pumps	Republic Flow Meters Co.
Soot blowers	Diamond Power Specialty Corp.
Pulverized-coal burners, 4; cap. each, 3,550 lb. per hr.	Babcock & Wilcox Co.
Coal pulverizers, 2; cap. each, 7,100 lb. per hr.	Babcock & Wilcox Co.
Pulverizer-driving motor, 150 hp., 695 r.p.m., 550 volts	Allis-Chalmers Mfg. Co.
Pulverizer-motor control	I-T-E- Circuit Breaker Co.
Primary-fan driving motor, 60 hp.	Allis-Chalmers Mfg. Co.
Primary-fan motor control	I-T-E- Circuit Breaker Co.
Coal feeders, 2	Babcock & Wilcox Co.
Coal-feeder driving motor, 1 hp.	Allis-Chalmers Mfg. Co.
Ignition torch	Babcock & Wilcox Co.
Forced-draft fan, 1; cap. 95,000 c.f.m.; static pressure 11.0 in., turbovane type, vane control	B. F. Sturtevant Co.
Forced-draft-fan drive, 250-hp., 1,200-r.p.m. motor	Allis-Chalmers Mfg. Co.
Forced-draft-fan motor control	I-T-E Circuit Breaker Co.
Connection between fan and drive	B. F. Sturtevant Co.
Induced-draft fan, 1; cap. 170,000 c.f.m.; static press., 17.0 in.	B. F. Sturtevant Co.
Induced-draft-fan drive, one 350-hp., 900-r.p.m. and one 800-hp., 1,200-r.p.m. motor	Allis-Chalmers Mfg. Co.
Induced-draft-fan motor control	I-T-E Circuit Breaker Co.
Connection between fan and drive	B. F. Sturtevant Co.

COAL-HANDLING EQUIPMENT:

Coal handling, apron feeder, belt conveyor and tripper	C. O. Bartlett & Snow Co.
Coal-hanadling equipment motors	Allis-Chalmers Mfg. Co
Motor controller	I-T-E- Circuit Breaker Co.
Coal crusher	American Pulverizing Co.
Crusher-driving motor, 100 hp.	Allis-Chalmers Mfa. Co.
Coupling on crusher motor	Falk Co.
Crusher motor control	I-T-E Circuit Breaker Co.
Maanetic separator	Stearns Magnetic Co.
Coal bunker	L. Schreiber Co.
Coal gates	Henry Pratt Co.
Coal scales	Richardson Scale Co.

ASH-HANDLING EQUIPMENT:

Ash-handling equipment on furnace	Allen-Sherman-Hoff Co.
Ash-handling equipment on flyash system	Allen-Sherman-Hoff Co.
Vacuum pumps on flyash-removal system	Allen-Sherman-Hoff Co.
Ash and soot precipitator, electrostatic	Research Corp.

VALVES:

Safety valves	Consolidated Ashcroft Hancock Co.
Blowdown valves	Lunkenheimer Co.
Forged-steel needle valves	Lunkenheimer Co.
Non-return valves	Edward Valve & Mfg. Co.
Stop and check valves in feed lines	Lunkenheimer Co.
High- and medium-pressure valves	Lunkenheimer Co.
Low-pressure valves	Wm. Powell Co. & Lunkenheimer Co.
Reducing valves	Republic Flow Meters Co.
Atmospheric relief valves	Consolidated Ashcroft Hancock Co.

PIPING, TRAPS AND STRAINERS:

Piping contractor	Pittsburgh Piping & Equipment Co.
Pipe insulation	Philip Carey Co.
High- and low-pressure traps	Armstrong Machine Works

FEEDWATER SYSTEM:

Water columns	Diamond Power Specialty Corp.
Feedwater regulators	Republic Flow Meters Co.
Excess-pressure regulators	Republic Flow Meters Co.
Boiler-feed pumps, 3; cap. each, 1,200 g.p.m.; 3,680-ft. head	Worthington Pump & Mach. Corp.
Feed-pump drive, 1,500-hp., 3,500-r.p.m., steam turbine	General Electric Co.
Feed-pump-speed regulating valves	Republic Flow Meters Co.
Feedwater purification equipment	Wm. B. Scaife & Sons Co.
Feedwater heaters	Griscom-Russell Co.
Feedwater-heater drainage regulator	Fisher Governor Co.
Heater condensate pumps, 2; cap. each, 120 g.p.m.; 360-ft. head	Yeomans Bros. Co.

METERS:

Boiler meter and control board	Republic Flow Meters Co.
Turbine meter and control board	Republic Flow Meters Co.
Boiler meters	Bailey Meter Co.
Temperature recorders	Leeds & Northrup Co.
Feedwater flowmeters	Builders Iron Foundry Co.
Boiler-water-level indicators	Diamond Power Specialty Co.
Water-pressure gages, indicating	Consolidated Ashcroft Hancock Co.
Turbine-pressure gages, indicating	Consolidated Ashcroft Hancock Co.
Turbine-pressure gages, recording	Republic Flow Meters Co.
Turbine-speed indicators	Esterline-Angus Co.
Thermometers, dial	Foxboro Co.
Temperature recorders	Republic Flow Meters Co.
Generator temperature recorder	Leeds & Northrup Co.
Draft gages, multiple-point	Republic Flow Meters Co.

GENERATING UNITS:

One, 35,000-kw., 3,600-r.p.m. steam turbine; throttle steam conditions, 1,200 lb. G, 900 F; exhausting at 260 lb. G.	Westinghouse Elec. & Mfg. Co.
Turbine connects directly to 43,750-k.v.a., 0.80-p.f., 3-phase, 60-cycle, 13,200-volt generator	Westinghouse Elec. & Mfg. Co.
Desuperheater	Republic Flow Meters Co.
Automatic desuperheater control	Republic Flow Meters Co.
Oil cooler	Westinghouse Elec. & Mfg. Co.
Oil purifier	DeLaval Steam Turbine Co. & S. F. Bowser Co.
Station switchboard	Marquette Elec. Switchboard Co.
Automatic voltage regulator	General Electric Co.
House switchboard	I-T-E Circuit Breaker Co.
Station transformers	Allis-Chalmers Mfg. Co.
Oil circuit breakers	Westinghouse Elec. & Mfg. Co.

OMAHA

A small extension seemed desirable; superposition provided it at a minimum over-all cost and conserved valuable space for a possible future condensing installation of large size. Normal operating troubles have been overcome and unit is now in commercial service

A 10,000-KW. high-pressure topping unit was placed in regular operation during July, 1937, at the Omaha Steam Electric Station of the Nebraska Power Company. On the bank of the Missouri River at Omaha, this station is most heavily loaded in summer because of the large refrigerating load from local meat-packing plants. A 10-deg. rise in temperature adds approximately 8,000 kw. to daytime load on the station.

Status Before Extension

Operation at two pressures is an old story at Omaha. The original station, started in 1906, operated at 195 lb. G and later changes added a 310-lb. G system. Prior to the extension, one 15,000-kw. turbine and several smaller units aggregating 12,000 kw. were supplied at 195 lb. and 520 F. One 25,000-kw. and two 20,000-kw. units were supplied at 310 lb. and 725 F. Steam was normally generated at the higher pressure, in five boilers equipped with chain-grate stokers, the low-pressure machines receiving steam through a reducing valve and desuperheater. The old low-pressure boilers were available for occasional operation as required.

In planning the extension at Omaha, a small increase in capacity seemed most desirable without looking too far into the future. The superposed installation finally selected showed the lowest total fixed and production costs of two topping proposals and two condensing proposals studied. In addition, the compactness of the superposed installation conserved valuable space for a projected large condensing extension.

A single chain-grate-stoker-fired steam generator furnishes the 275,000 lb. per hr. of 1,200-lb., 900-F steam required to drive the new high-pressure turbine at maximum output. The top exhausts at 195 lb. to an existing 15,000-kw. machine. This combination is intended to be operated as a unit.

Reliable operation of the 21-year-old low-pressure turbine was assured by a thorough examination and overhaul. The condenser was retubed and new condensate pumps installed.

Heat Balance

The intention of operating the high- and low-pressure turbines as a unit dictated to a certain extent the heat-balance arrangement. Neither turbine is equipped for bleeding; feedwater is heated by 195-lb. steam and by waste heat from oil and air coolers. The main condensate flows first to the low-pressure-turbine oil cooler, then through the steam-jet air-pump condenser and in succession through the air cooler, oil cooler and gland steam leak-off condenser of the high-pressure machine. Make-up is heated to 215 F and, after evaporation, joins condensate in the deaerating heater. At 10,000-kw. load, feedwater leaves the deaerator at 254 F, passes through the turbine-driven boiler-feed pump and is heated to 384 F in a crossover heater, before entering the economizer.

To insure operating flexibility, two reducing stations are provided; a new 1,200-lb., 310-lb. station ties the new high-pressure system to the old intermediate-pressure system, and the existing 310-lb., 195-lb. station connects the old intermediate- and low-pressure systems.

Steam-Generating Unit

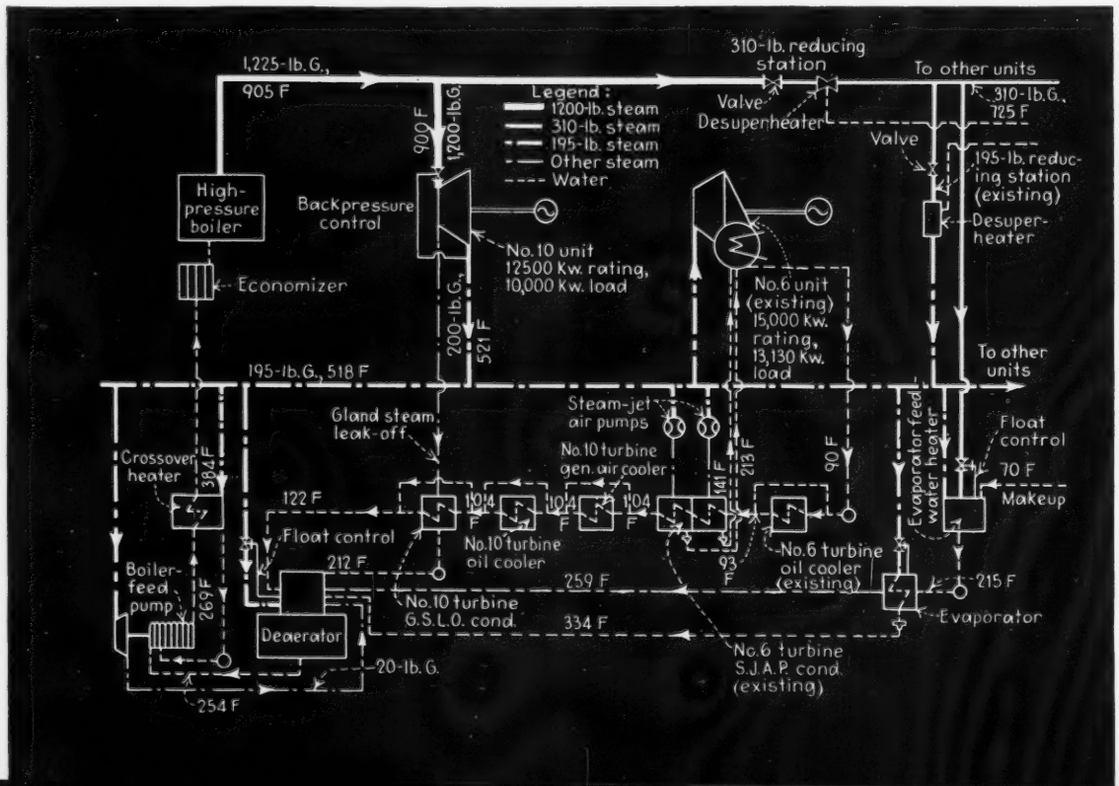
The 3-drum, bent-tube, Combustion boiler has a total heating surface of 15,500 sq.ft., of which 12,000 is in the boiler proper and 3,500 is water-wall surface. A damper above the superheater tube nest in the second pass controls steam temperature by permitting a portion of the gas to bypass the superheater. The boiler casing also houses the 18,130-sq.ft. economizer.

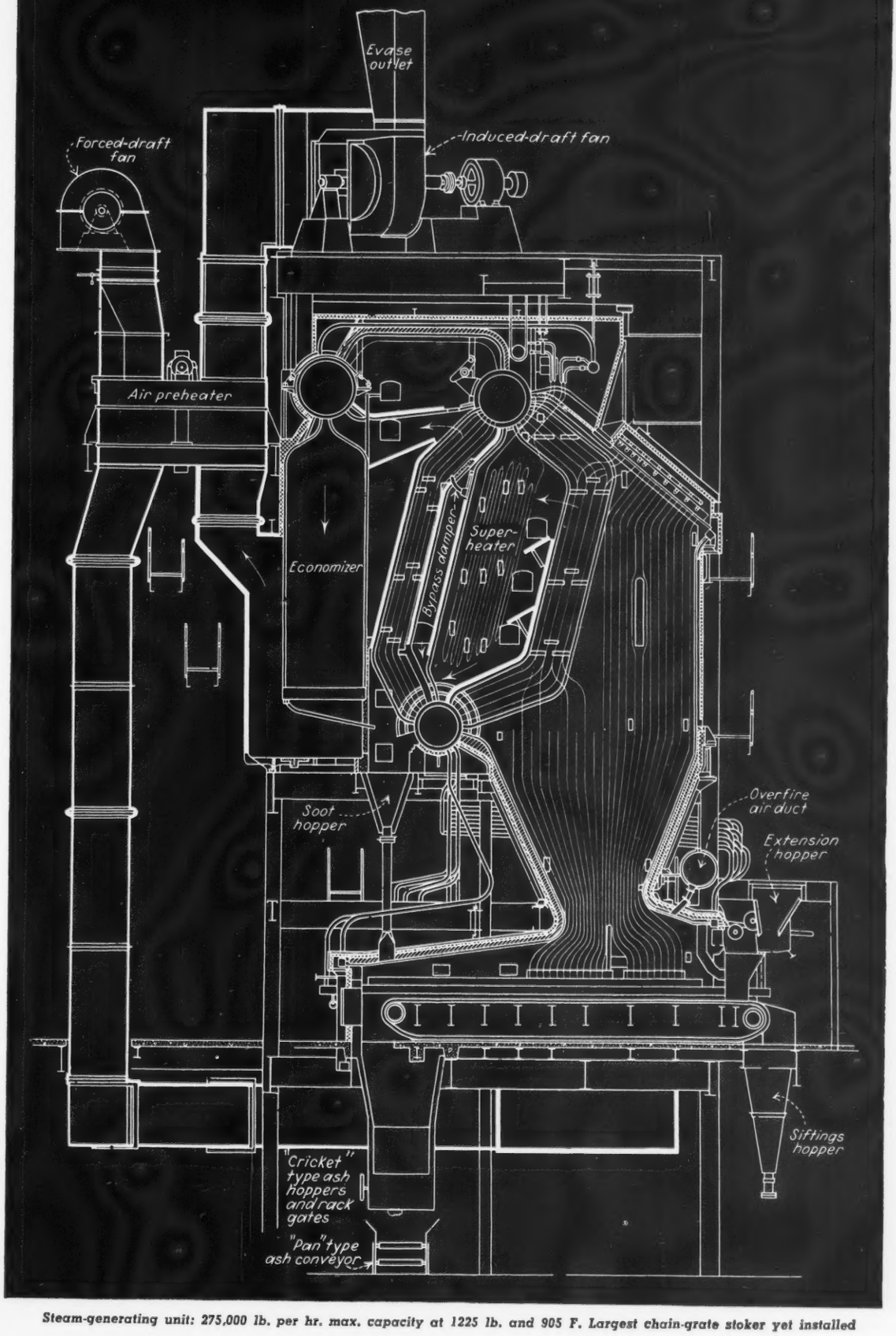
A maximum heat liberation of 37,600 B.t.u. per cu.ft. per hr. is obtained in the 9,400-cu.ft. furnace. To cope with the slagging tendencies of Kansas coals, numerous lancing doors have been installed, particularly at the head of the furnace.

The chain-grate stoker has a projected grate area of 569 sq.ft., making it the largest of the type yet installed. A constant-speed motor drives the stoker through a variable-speed transmission of the mechanical type.

Air supply is preheated in a 12,250-sq.ft. Ljungstrom heater directly behind the top drum. A 96,000-c.f.m. fan driven by a single-speed motor provides primary air, and a 10,000-c.f.m. fan supplies secondary air.

Flow diagram: High- and low-pressure turbines operate as a unit; two reducing stations provide flexibility and reliability





Steam-generating unit: 275,000 lb. per hr. max. capacity at 1225 lb. and 905 F. Largest chain-grate stoker yet installed

Secondary or overfire air enters the furnace from a duct at the front, near the extension hopper.

Furnace gas is handled by two 78,500-c.f.m. fans driven by variable-speed slip-ring motors. The thirteen speeds are controlled by pushbutton from the boiler panel; they cover the high flow range, while the low flows are regulated by the boiler outlet damper. Both this damper and the windbox damper are pushbutton controlled from the boiler panel.

Coal and Ash Handling

Segregation of coal is prevented and uniform fire conditions across the width of the stoker are achieved by swinging coal spouts, actuated by oil pressure cylinders. This is similar to the arrangement on the old boilers.

A pan ash conveyor in the boiler basement is fed from cricket-type ash hoppers with rack gates, and discharges into a similar conveyor running at right angles.

A bucket conveyor serves both coal-

and ash-handling systems, raising coal from pit storage to conveyors supplying overhead bunkers, and ash from basement conveyors to storage bunkers.

The 3,600-r.p.m. General Electric turbine drives a 3-phase, 60-cycle, 13,800-volt generator, rated 12,500 kva. at 0.85 power factor. An eccentricity recorder is to be installed, and stage pressures are being watched carefully, as some evidence of blading deposit has been noticed.

Operating Experience

Normal operating troubles marked starting and testing of the high-pressure unit but no major design changes were necessary to permit operation as contemplated. Present early indications are that design economy has been achieved.

From initial operation Feb. 14, 1937, to Aug. 5, the high-pressure turbine has been in service 1,790 hours, or 43% of the total period. The boiler, first fired Feb. 8, has operated 3,011 hours, or 70% of the total period.

The stoker operates well, the fire line being straight and well defined. The flame extends out 4 or 5 ft. from the front wall, and the remainder of the furnace is clear, without smoke. No indication of fan-wheel erosion, and no cinder accumulation in the hoppers both constitute evidence of the relative freedom from cinder. Slag removal is satisfactorily accomplished by one man working less than one hour per shift.

Deposits containing sulphur necessitate occasional cleaning of the air preheater. Washing with cold water has been found effective.

Starting and Stopping

Development of a sound procedure for starting and stopping the new boiler has been important in preventing leaks due to expansion and contraction.

In starting, the fire is built gradually on natural draft. About four hours is allowed before steaming. The boiler then steams through the superheater and down vents for about an hour, after which pressure is increased by slowly closing the vents. The boiler is cut-in on the 310-lb. header through the reducing station and delivers in the neighborhood of 50,000 lb. per hr.

The increase in boiler pressure continues at a rate of about 100 lb. per hr. until 800 lb. is reached, when the turbine is started. Starting at this pressure prevents the excessively high steam temperature which would result in the low-pressure turbine if full pressure were applied to the unloaded high-pressure machine. During the four to five hours taken to build pressure up to 800 lb., flow is permitted to increase to roughly 100,000 lb. per hr.

Forced draft is applied, and during the next hour boiler pressure rises to 1,100 lb. and the turbine begins to take load. Total starting time is 10 to 12 hours.

In shutting down, the pressure on the boiler is reduced gradually with the reducing station passing about 100,000 lb. per hr. The pressure falls to 400 lb. during the 3-hour interval in which the fire is burning down. The vents are opened gradually and the boiler is allowed to cool slowly. It takes close to 20 hours to lower the pressure below 100 lb.

PRINCIPAL EQUIPMENT IN OMAHA STEAM-ELECTRIC STATION

Nebraska Power Co., Omaha, Neb.

Consulting Engineers.....Ebasco Services, Incorporated
Boilers and waterwalls.....Combustion Engineering Corp.
Boiler heating surface, 12,000 sq.ft.; waterwalls, 3,500 sq.ft.; max. continuous steaming cap. 275,000 lb. per hr.; working press., 1,350 lb. G.; total steam temp., 910 F; furnace volume, 9,400 cu.ft.; max. B.t.u. liberated per cu.ft. per hr., 37,600
Superheater, 9,700 sq.ft.....The Superheater Co.
Economizer, 18,130 sq.ft.....The Superheater Co.
Steam washer, cap., 275,000 lb. per hr..Combustion Engineering Corp.
Air heater, 12,250 sq.ft., Ljungstrom type.....Air Preheater Corp.
Boiler and furnace settings.....Combustion Engineering Corp.
Furnace refractories .....A. P. Green Fire Brick Co.
Stoker ignition arch.....American Arch Co.
Boiler ducts and breechings.....Combustion Engineering Corp.
Structural steel.....Omaha Steel Works and Paxton & Vierling Co.

COMBUSTION EQUIPMENT:

Soot-blowers.....Diamond Power Specialty Corp.
Stoker, chain-grate type; projected grate area 569 sq.ft. Combustion Engineering Corp.
Stoker drive, 10-hp., 1,800-r.p.m. motor.....General Electric Co.
Speed control, variable-speed transmission.....Reeves Pulley Co.
Forced-draft fan, capacity, 96,000 c.f.m.; static pressure 8.0 in. American Blower Corp.
Forced-draft-fan drive, 200-hp., 1200-r.p.m., squirrel-cage motor General Electric Co.
Overfire-air fan, capacity, 10,000 c.f.m.; static pressure 4.0 in. American Blower Corp.
Overfire-air fan drive, 10-hp., 1800-r.p.m., squirrel-cage motor General Electric Co.
Induced-draft fans, 2; cap. each, 78,500 c.f.m.; static press. 13.2 in. American Blower Corp.
Induced-draft-fan drives, 2; 300-hp.; 900-r.p.m., slip-ring motors General Electric Co.
Induced-draft-fan motor controls.....Westinghouse Elec. & Mfg. Co.

COAL-HANDLING EQUIPMENT:

Coal-handling, flight-belt conveyor and tripper.....Chain Belt Co.
Skip hoist.....Chain Belt Co.
Coal-handling equipment motors.....Allis-Chalmers Mfg. Co.
Coal Crusher.....Williams Patent Crusher & Pulverizer Co.
Coal-crusher motor, 40-hp., 900 r.p.m.....Allis-Chalmers Mfg. Co.
Coupling on crusher motor, Fast.....Koppers Co.

ASH-HANDLING EQUIPMENT:

Ash-handling equipment on furnace, belt and pan conveyors Chain Belt Co.

VALVES:

Safety valves.....Consolidated Ashcroft Hancock Co.
Blowdown valves.....Yarnall-Waring Co.
Non-return valves.....Edward Valve & Mfg. Co.
Stop and check valves in feed lines Chapman Valve Mfg. Co. and Edward Valve & Mfg. Co.
Medium- and low-pressure valves.....Reading, Pratt & Cady Co.
Reducing valves.....General Regulator Corp.
Atmospheric relief valves.....Atwood & Morrill
Electric valve operators Philadelphia Gear Works and Chapman Valve Mfg. Co.

PIPING, TRAPS AND STRAINERS:

Piping contractor.....National Valve & Mfg. Co.
Pipe insulation.....Philip Carey Co.
Expansion joints.....E. B. Badger & Sons
Low-pressure traps Armstrong Machine Works and Strong, Carlisle & Hammond Co.

FEEDWATER SYSTEM:

Water columns .....Diamond Power Specialty Corp.
Feedwater regulators.....Republic Flow Meters Co.
Boiler-feed pumps, 2; capacity each, 660 g.p.m.; 3910 ft. head Worthington Pump & Mach. Corp.
Feed-pump turbines, 2; 1150-hp. each; 3650 r.p.m. Westinghouse Elec. & Mfg. Co.
Feed-pump speed-regulating valves.....Republic Flow Meters Co.
Make-up water pump, capacity 12 g.p.m. Worthington Pump & Mach. Corp.
Make-up water pump drive, 3-hp. motor.....General Electric Co.
Evaporator, 5000-lb.-per-hr. cap.....Griscom-Russell Co.
Feedwater-deaerating heater.....Elliott Co.

METERS:

Boiler meter.....Bailey Meter Co.
Steam-flow, pressure and temp. recorders Bailey Meter Co., Foxboro Co., Leeds & Northrup Co.
Feedwater flowmeters.....Bailey Meter Co.
Boiler water-level recorders.....Foxboro Co.
Condensate tester.....Leeds & Northrup Co.
Steam-pressure gages, indicating.....Crosby Steam Gage & Valve Co.
Water-pressure gages.....Crosby Steam Gage & Valve Co.
Thermometers, industrial.....Taylor Instrument Companies
Thermometers, dial.....Taylor Instrument Companies
Temperature recorders, multiple-point.....Leeds & Northrup Co.

GENERATING UNITS:

One, 10,000-kw., 3600-r.p.m., steam turbine; throttle steam conditions 1200 lb. G., 900 F; exhaust pressure 200 lb. G. General Electric Co.
Turbine connects directly to 12,500-kva., 0.85-p.f., 3-phase 60-cycle, 13,800-volt generator.....General Electric Co.
Generator air coolers.....General Electric Co.
Oil purifier.....F. S. Bowser & Co.
Condensate pumps, 2; 450 g.p.m.....Foster Wheeler Corp.
Condensate pump driving motors, 2; 50-hp., 1800-r.p.m., 440-volt squirrel-cage motors.....General Electric Co.
Station switchboard .....General Electric Co.
Oil circuit breakers.....General Electric Co.

INDUSTRIAL & INSTITUTIONAL PLANTS 200 LB. & UNDER

Units Installed Since Jan. 1, 1936

	Name of Company and Location	Kind of Industry	New, Addition or Replacement	First Operation, New Units	BOILERS							GENERATING UNITS				
					Number	Straight or Bent Tube	Max. Cap. Each 1,000 Lb. per Hr.	Gage Pressure, Lb. per Sq. In.	Steam Temp. Deg. F.	Heating Surf., 1,000 Sq. Ft. Each	Furnace Volume, 1,000 Cu. Ft.	Type of Firing Equipment	Power Unit, Type	Number	Capacity Each 1,000 Kw.	Extraction Pressure Lb. per Sq. In. G	Exhaust Press., Lb. per Sq. In. ABS
INDUSTRIAL	Spang Chalfant & Co., Ambridge, Pa.	Pipe	Add	1937	1	B	37.5	200	Sat.	5.2	....	U.S.				
	American Coating Mills, Elkhart, Ind.		Add	....	4	..	30	200	Sat.	....	....	O.S.	C.E.T.	1	2.5	15	1.0
	Cornell Wood Products Co., Cornell, Wis.	Paper	....	1936	1	B	75	200	700	8.0	3.8	P.C.			....	....	....
	Bogota Paper & Board Corp., Bogota, N. J.	Paper	....	1937	1	B	50	200	500	6.0	2.0	T.G.S.			....	....	....
	General Cable Co., Bayonne, N. J.	Cable	....	1937	1	B	....	200	Sat.	5.1	....	Oil		1	1.5	....	....
														1	1.25	....	....
	Continental Can Co., Chicago, Ill.	Can	New	1936	3	S	22.5	200	Sat.	10.5	1.1	P.C.			....	....	....
	Caterpillar Tractor Co., Peoria, Ill.	Eng. & Rd. Mach.	Add	1937	1	..	40	200	Sat.	6.2		St.					
	Hiler Engr. & Const. Co., Providence, R. I.		....	1936	2	..	24	200	493	6.8	1.2	W.G.	C.T.	2	1.25	....	....
	Int. Harvester Co., Springfield, O.	Agr. Mach.	....	....	3	..	60	200	....	5.3	....	U.S.			....	....	....
	Seagram Distilling Co., Lawrenceburg, Ind.	Distillery	....	....	1	..	70	200	....	8.0	....	P.C.					
	Brehm & Stehle, Inc., Philadelphia, Pa.		....	....	1	..	30	200	....	4.3	....	P.C.	Eng.	2	0.40	....	....
	Shell Oil Co., Martinez, Cal.	Oil	Add	1936	1	B	70	200	540	5.3	2.4	Gas-Oil			....	....	....
	Shell Oil Co., Dominguez, Cal.	Oil	Add	1936	1	B	60	200	488	6.9	3.1	Gas-Oil			....	....	....
	Klise Mfg. Co., Grand Rapids, Mich.		....	....	1	..	17	200	Sat.	2.2	0.61	S.S.			....	....	....
	Shell Oil Co., San Francisco, Cal.	Oil	....	....	2	..	10	200	488	2.0	0.7	Gas					
	Evenson & Levering Co., Camden, N. J.	Scouring Wool	Add	1937	..	..	....	195	....	....	....	....	B.P.T.	1	0.17	....	115
	Somersville Mfg. Co., Somersville, Conn.	Woolens	Add	1937	1	S	40	190	480	5.9	1.0	Oil	B.P.T.	1	0.625	....	25
	Columbia Mills, Inc., Minetta, N. Y.	Textile	....	....	..	..	....	185	500	....	....	....	C.E.T.	1	1.5	17–80	1.0
	Empire Trust Bldg., New York, N. Y.		....	....	2	..	14	185	....	2.3	....	Oil	Eng.	2	0.15	....	....
	Sonoco Products Co., Hartsville, S. C.		....	....	..	..	....	185	....	....	....	....	B.P.T.	1	1.25	....	40
	Detroiter Hotel, Detroit, Mich.	Hotel	....	1937	2	S	9	180	....	1.4	0.3	U.S.	Eng.	1	0.25	....	20
					1	B	17		....	2.5	0.049	....	....	....	....	....	....
	United Dairy Co., Barnesville, O.	Dairy	....	....	1	B	23	180	....	3.5	0.064	U.S.	Eng.	1	....	....	20
	Crompton & Knowles Loom Wks., Worcester, Mass.	Textile Mach.	....	1937	..	..	....	....	....	....	....	....	B.P.T.	1	0.20	2	17
													B.P.T.	1	0.5	....	3.5
	Nelson Tanning Corp., Muskegon, Mich.	Tanning	Add	1937	1	B	16.5	180	480	2.0	0.6	S.S.	Eng.	1	0.2	....	3.5
													B.P.T.	1	0.50	....	50
	Armstrong Cork Co., Camden, N. J.	Cork	....	....	..	..	....	....	....	....	....	....	....	....	....	....	....
	Armour & Co., North Bergen, N. J.	Meat	Rep.	1937	2	B	60	180	430	6.1	2.5	Oil					
	J. Breckwolelt & Son, Inc., Dolgeville, N. Y.	Piano Parts	....	1936	1	S	....	180	....	2.9	....	Wood	Eng.	1	0.40	....	20
	Conway Bldg., Chicago, Ill.			1936	4	..	22	180	....	3.0	....	Gas			....	....	....
	Holly Sugar Co., Hardin, Mont.	Sugar	New	1937	3	B	71	175	Sat.	8.3	....	C.G.S.	B.P.T.	1	1.0	....	29.7
													Eng.	1	0.25	....	....
	W. B. Conkey Co., Hammond, Ind.		New	1937	2	B	....	175	428	....	12.0	Oil	C.T.	1	0.25	....	....
	Syracuse Chilled Plow Co., Syracuse, N. Y.	Agr. Mach.	Add	1936	1	S	17.2	175	473	3.6	....	S.S.	Eng.	1	0.35	....	20
	Ellicott Sq. Bldg., Buffalo, N. Y.		....	1936	4	..	5.0	175	Sat.	....	....	U.S.	B.P.T.	1	0.625	....	....
	Port Huron Sul. & Paper Co., Pt. Huron, Mich.	Paper	....	1937	..	..	....	....	....	....	....	....	C.E.T.	1	1.3	30	1.0
	Spencer Kellogg & Sons, Buffalo, N. Y.	Coal	....	1937	1	B	10	160	Sat.	2.1	....	U.S.	....	..	....	....	....
	General Motors Corp., Inland Div., Dayton, O.	Automobile	....	....	1	..	80	160	....	7.0	2.9	P.C.	....	....	....	....	....
	N. N. Shipbldg. & D. Dock Co., Newport News, Va.	Shipbuilding	....	....	..	..	....	....	....	....	....	....	C.E.T.	1	2.0	10–30	....
	Stanley Works, New Britain, Conn.	Hardware	Rep.	1936	2	B	30	160	520	3.9	....	....	....	....	....	....	....
	Dairymen's Coop. League, Adams, N. Y.	Dairy	New	1937	2	B	25	160	Sat.	3.3	0.6	U.S.	....	....	....	....	....
	Great Western Sugar Co., Billings, Mont.	Sugar	Add	1936	3	..	125	160	Sat.	12.9	3.3	C.G.S.	....	....	....	....	....
													....	....	....	....	....
	Continental Mills, Inc., Philadelphia, Pa.		....	....	2	..	....	160	....	....	....	St.	Eng.	1	0.125	....	....
														4	0.25	....	19.5
	A. Gross & Co., Newark, N. J.		....	....	2	..	12	160	....	3.9	0.6	U.S.	....	..	....	....	....
	American Cream Tartar Co., San Francisco, Cal.		....	....	1	..	20	160	Sat.	3.2	0.8	Gas-Oil	....	....	....	....	....
	Bethlehem Steel Co., Lackawanna, N. Y.	Steel	....	1936	4	..	30	160	566	5.1	2.0	T.G.S.	....	....	....	....	....
	Benett Creamery, Inc., Ottawa, Kan.		....	....	2	..	10.3	160	....	4.6	2.1	Gas	....	....	....	....	....
	Libby Glass Co., Toledo, O.	Glass	....	1936	1	..	22	160	Sat.	3.2	0.4	U.S.	....	....	....	....	....
	Libby, Owens, Ford Glass Co., Toledo, O.	Glass	....	....	2	..	103	160	....	11.0	4.1	P.C.	....	....	....	....	....
	American Crystal Sugar Co., Rocky Ford, Col.	Sugar	Add	1936	..	..	....	155	Sat.	....	....	....	B.P.T.	1	1.25	....	33
	Bigelow Sanford Carpet Co., Thompsonville, Conn.	Carpet	Add	1937	..	..	....	....	....	....	....	....	B.P.T.	1	1.5	15	30
	Mallinckrodt Chemical Wks., St. Louis, Mo.	Chemical	....	1937	..	..	....	....	....	....	....	....	Eng.	1	0.30	....	22
	Ohio Salt Co., Rittman, O.	Salt	....	....	..	..	....	....	....	....	....	....	B.P.T.	1	1.0	....	20–45
	Little Falls Laundry, Little Falls, N. J.	Laundry	Add	1936	1	B	60	150	Sat.	6.1	1.1	P.C.	....	....	....	....	....
	Thermoid Co., Trenton, N. J.	Rubber	New	1936	1	B	300	150	Sat.	4.5	....	C.G.S.	....	....	....	....	....
														1	0.6	....	....
	Riverside Metal Corp., Riverside, N. J.	Metal	....	1936	1	B	65	150	516	6.4	3.3	P.C.	Eng.	1	0.3	....	2.0
	National Sugar Ref. Co., Edgewater, N. J.	Sugar	Rep.	1937	..	..	....	....	....	....	....	....	B.E.T.	1	1.25	50	27
	Union Mfg. Co., New Britain, Conn.	Foundry	Rep.	....	1	S	10	150	Sat.	....	....	H.S.	....	....	....	....	....
	Aluminum Co. of America, New Kensington, Pa.	Aluminum	Add	1937	1	S	140	150	500	18.0	5.3	U.S.	B.P.T.	1	1.25	....	20
	Gair Cartons, Inc., Piermont, N. Y.		....	....	7	..	....	150	....	3.0	....	C.G.S.	C.E.T.	1	2.0	10	....
	Publicker Comm. Alcohol Co., Philadelphia, Pa.	Alcohol	Add	1937	1	B	275	150	415	19.4	15.6	Oil	....	....	....	....	....
	Avery Salt Co., Avery Is., La.	Salt	....	....	..	..	....	140	....	....	....	....	B.P.T.	1	0.75	....	20
													Eng.	1	.007	....	....
	Nelson Distillery, Inc., Bardstown, Ky.	Distillery	New	1937	2	B	15	135	Sat.	1.8	0.2	H.	Eng.	1	.035	....	....
	Muscogee Mfg. Co., Columbus, Ga.	Textile	Add	1936	1	B	42	130	Sat.	7.4	1.8	Gas	....	....	....	....	....
	E. I. DuPont de Nemours & Co., Niagara, N. Y.	Chemical	Add	1937	1	S	70	130	Sat.	8.5	3.2	U.S.	....	....	....	....	....
	E. I. DuPont de Nemours & Co., Wilmington, Del.	Chemical		1936	2	..	45	125	....	7.0	....	Oil	....	....	....	....	....
	Libby, McNeil & Libby, Inc., Walla Walla, Wash.	Packing	Add	1936	1	B	18	125	Sat.	3.1	....	U.S.	....	....	....	....	....
	I. Sonneborn Sons, Inc., Petrolia, Pa.	Oil	....	1936	1	B	35.9	125	Sat.	5.5	....	A.S. / Coke	....	....	....	....	....
	E. I. DuPont de Nemours & Co., New Bridge, Ill.	Chemical	....	1936	1	..	30	125	....	5.0	2.1	Oil	....	....	....	....	....
	Meadow River Lumber Co., Rainelle, W. Va.	Lumber	Add	1936	..	..	....	....	....	....	....	....	C.T.	1	2.0	....	0.75
	Imperial Paper & Color Co., Glens Falls, N. Y.	Pap. & Pig. Col.	New	1936	2	B	50	125	Sat.	6.1	1.2	T.G.S.	....	....	....	....	....
	Cliffs Dow Chemical Co., Marquette, Mich.	Chemical		1936	..	..	....	120	....	....	....	....	B.E.T.	1	1.0	30	....
	Lehigh Valley Coal Co., Wilkes Barre, Pa.	Coal	....	....	..	..	....	115	....	....	....	....	Eng.	1	0.42	....	20
	Evening News Publishing Co., Newark, N. J.	Publishing	....	....	..	..	....	....	....	....	....	....	C.T.	1	1.0	....	....
														1	0.5	10	....
	American Woolen Co., Lawrence, Mass.	Textile	....	....	..	..	....	....	....	....	....	....	....	1	5.0	10 100	....
													B.E.T.	1	2.0	150	....
	Garden City Co., Garden City, Kan.		....	....	..	..	....	....	....	....	....	....	....	....	....	....	....
GOVERNMENT & INSTITUTIONAL	Norfolk Navy Yard, Norfolk, Va.		....	....	..	..	....	190	428	....	....	....	C.E.T.	1	6.0	20	....
	U. S. Military Academy, West Point, N. Y.			1937	2	..	100	160	Sat.	10.0	2.9	St.	B.P.T.	2	1.0	....	22
	U. S. Dept. of Labor, Ellis Island, N. Y.		....	....	..	..	....	125	....	....	....	....	B.P.T.	1	0.40	....	....
	U. S. Bureau of Docks & Yards, Norfolk, Va.		Add	1937	1	B	40	125	Sat.	6.0	1.9	Oil	....	..	....	....	....
	Alabama Insane Hospital, Tuscaloosa, Ala.		....	1936	1	B	50	180	379	8.3	4.0	St.	....	....	....	....	....
	Vocational School, Philadelphia, Pa.		....	1937	3	..	25.8	175	....	3.7	....	C.G.S.	Eng.	1	0.30	....	20
													Eng.	2	0.50	....	20
	University of Kentucky, Lexington, Ky.		....	....	1	..	42.5	175	475	....	....	S.S.	....	..	....	....	....
					3	B	50.0	175	475	5.0	2.0	P.C.	....	..	....	....	....
	Taunton State Hospital, Taunton, Mass.		....	1936	2	B	20.0	165	....	6.2	....	Oil	....	..	....	....	....
	Berea College, Berea, Ky.		....	1937	2	..	3.8	....	....	....	....	....	....	..	....	....	....
					4	..	2.9	160	Sat.	....	....	U.S.	C.E.T.	3	1.0	....	....
	Vanderbilt University, Nashville, Tenn.		Add	1937	1	B	35	160	Sat.	5.8	1.1	U.S.	....	..	....	....	....
	St. Olaf College, Northfield, Minn.		Add	1937	1	..	26.8	160	Sat.	4.2	....	Gas	B.P.T.	1	0.30	....	17
	University of New Mexico, Albuquerque, N. M.		New	1937	2	B	20	160	Sat.	3.2	0.9	Gas	....	..	....	....	....
	University of Alabama, Tuscaloosa, Ala.		Add	1937	1	S	35	160	Sat.	5.1	....	U.S.	....	..	....	....	....
	Orange Memorial Hospital, Orange, N. J.		Add	1937	1	S	16	160	Sat.	2.2	0.7	Oil	....	..	....	....	....
	Kansas State Juvenile Home, Winfield, Kan.		Add	1936	1	S	15.7	160	Sat.	3.5	....	Gas	....	..	....	....	....
	Coney Island Hospital, New York, N. Y.		....	....	2	..	....	160	....	2.6	....	U.S.	B.P.T.	..	1.25	....	....
	Seaview Hospital, New York, N. Y.		Rep.	1936	2	S	30	150	Sat.	6.2	....	T.G.S.	Eng.	2	....	....	20
	Maryland Tuberculosis Sanitarium, Sanitarium, Md.		Add	1936	1	B	....	150	Sat.	2.9	....	U.S.	Eng.	2	0.125	....	19
	Newberry State Hospital, Newberry, Mich.		....	....	3	..	30	150	....	12.7	....	U.S.	Eng.	3	0.483	....	....
	Rockland State Hospital, Orangeburg, N. Y.		Add	....	..	..	34	150	Sat.	8.6	....	....	B.P.T.	1	1.25	....	15
	Felician Sister's Convent, Plymouth, Mich.		....	1936	2	B	20	145	Sat.	7.2	....	T.G.S.	Eng.	1	0.10	....	17
	Veterans Administration Facility, Kecoughtan, Va.		Rep.	1936	2	B	12.1	125	Sat.	....	....	S.S.	....	..	....	....	....
					2	B	17.3	125	Sat.	....	....	S.S.	Eng.	2	0.25	....	....

FURTHER INDUSTRIAL & INSTITUTIONAL PLANTS

In addition to plants included in the tables of Section II and on the preceding page, the following industries and institutions are known to have installed power equipment since Jan. 1, 1936

INDUSTRIAL PLANTS

Albemarle Chesapeake Co., West Point, Va.
Allied Kid Co., Phila., Pa.
Allied Paper Mills, Kalamazoo, Mich.
Allis-Chalmers Mfg. Co., Springfield, Ill.
Amalgamated Sugar Co., Paul, Idaho
American Bomberg Corp., Elizabethton, Tenn.
American Brass Co., Kenosha, Wis.
American Brewing Co., Rochester, N. Y.
American Crystal Sugar Co., Chaska, Minn.
American Linen Supply Co., Minneapolis
American Maize Products Co., Roby, Ill.
American Thread Co., Fall River, Mass.
American Woolen Co., Webster, Mass.
Arlington Mills Inc., Lawrence, Mass.
Armour & Co., Bismarck, N. D.
Armour Leather Co., Newberry, Pa.
Armstrong Cork Co., Beaver Falls, Pa.
Ash Grove Lime & Cement Co., Chanute, Kan.
Ashland By-Products Co., Ashland, Ky.
Associated Laundries Inc., Wilmington, Del.
Atlantic Refinery Co., Phila., Pa.
Auglaize Box Board Co., St. Mary's, O.

Baker Castor Oil Co., Bayonne, N. J.
Ballantine & Sons, Inc., Newark, N. J.
Bardstown Distillery Inc., Bardstown, Ky.
Barnsdall Ref. Corp., Corpus Christi, Tex.
Bathurst Pr. & Paper Co., Bathurst, N. B.
Bemis Bros. Bag Co., Bklyn, N. Y.
Benjamin Moore & Co., Carteret, N. J.
Bethlehem Steel Corp., Sparrows Pt., Md.
Blackstone Hotel, Chicago, Ill.
Bolta Rubber Co., Lawrence, Mass.
Brown Co., Berlin, N. H.
Buckeye Cotton Oil Co., Memphis, Tenn.
Buckeye Steel Castings Co., Columbus, O.
Buffalo Electro Chem. Co., Buffalo, N. Y.
Buffalo Forge, New Iberia, La.
Burroughs Adding Mach. Co., Plymouth, Mich.
Butchers Slaughtering & Melting Assn., Brighton, Mass.

Carbide & Carbon Chemical Corp., S. Charleston, W. Va.
Carnegie Illinois Steel Co., Youngstown, O.
Castanea Paper Co., Johnsonburg, Pa.
Celluloid Corp., Newark, N. J.
Century Distilling Co., Peoria, Ill.
C. G. Conn Co., Elkhart, Ind.
Chevrolet Corp., Detroit, Mich.
Chevrolet Corp., Tonawanda, N. Y.
Clinton Cotton Mills, Inc., Clinton, S. C.
Colcord Coal Co., Montcoal, W. Va.
Colorado Utah Coal Co., Mt. Harris, Col.
Commonwealth Ice & Cold Storage Co., Boston
Consolidated Ashcroft Hancock Co., Bridgeport, Conn.
Consolidated Badger Cooperative, Shawano, Wis.
Consol. Chemical Industries, Woburn, Mass.
Container Corp. of America, Carthage, Ind.
Crawford Laundry Co., Bridgeport, Conn.
Crompton-Shenandoah Co., Waynesboro, Va.
Crossett Lumber Co., Crossett, Ark.
Cudahy Packing Co., Albany, Ga.
Cummins Distilleries Corp., Athertonville, Ky.

Dayton Co., Minneapolis, Minn.
Defiance Milk Prod. Co., Defiance, O.
Delaware Trust Bldg. Corp., Wilmington, Del.
Duquesne Brewing Co., Pittsburgh, Pa.
Durkee Family Foods Inc., Louisville, Ky.

E. I. du Pont de Nemours & Co., Seneca, Ill.
Electromotive Corp., McCook, Ill.
Elger Co., Fort City, Pa.
Elliott & Co., Duluth, Minn.
Elm City Brewing Co., Hartford, Conn.
Ethyl-Dow Chemical Co., Wilmington, N. C.
Evans Milling Co., Indianapolis, Ind.

F. C. Huyck & Sons, Albany, N. Y.
Fibre Board Prod. Co., Stockton, N. J.
Fibre Board Prod. Co., Vernon, Cal.
F. W. Cook Co., Evansville, Ind.
Gair Co. of Canada, Toronto, Ont., Can.
Galland Merc. Laundry Co., San Francisco
General Mills, Inc., Chicago, Ill.
Gluek Brewing Co., Minneapolis, Minn.
Gordon Woolen Co., Norwood, Mass.

Hamond & Irving Inc., Auburn, N. Y.
Harvard Brewing Co., Lowell, Mass.
Heekin Can Co., Cincinnati, O.
Hercules Powder Co., Parlin, N. J.
Hercules Powder Co., Wilmington, Del.
Hergert Realty Co., New York, N. Y.
Heyden Chemical Co., Garfield, N. J.
H. H. Robertson Co., Ambridge, Pa.
Hotel Adolphus, Dallas, Tex.
Hotel Lombardy, New York, N. Y.
Hurley Mach. Co., Chicago, Ill.

Ice Club, New York, N. Y.
Imperial Furniture Co., Grand Rapids, Mich.
Inland Steel Co., Indiana Harbor, Ind.
International Harvester Co., E. Moline, Ill.

Jacob Ruppert Brewery, Bklyn., N. Y.
Jacob Schmidt Brewing Co., St. Paul, Minn.
John Shillito Co., Cincinnati, O.
Jos. Seagram & Sons, Lawrenceburg, Ind.
Jos. Seagram & Sons, Louisville, Ky.

Kimble Glass Co., Vineland, N. J.
Kieckhefer Container Co., Plymouth, N. C.
King & Knox Gelatine Co., Camden, N. J.
Koppitz Melchers Inc., Detroit, Mich.
Kraft Paper Corp., Fernandina, Fla.
Kraft-Phenix Cheese Corp., Hartford, Wis.

Ladish Stoppenbach Co., Milwaukee, Wis.
Lewiston Bleachery Co., Lewiston, Me.
Loose-Wiles Biscuit Co., Kansas City, Mo.
Louisville Cement Co., Speed, Ind.

Magnetic Pigment Co., Trenton, N. J.
Malleable Iron Fittings Co., Cranford, Conn.
Manchester Bd. & Paper Co., Richmond, Va.
Manchester Board & Paper Co., Roanoke Rapids, N. C.
Manchester Bd. & Paper Co., West Point, Va.
Masonite Corp., Laurel, Miss.
Meadville Pa. Distilling Co., Meadville, Pa.
Mercantile Dye Works, New York, N. Y.
Michigan Carton Co., Battle Creek, Mich.
Midvale Steel Co., Nicetown, Pa.
Minneapolis Moline Imp. Co., Hopkins, Minn.
Montgomery-Ward & Co., Kansas City, Mo.
Moore Steam Turbine Co., Wellsville, N. Y.
Morris Paper Mills, Chicago, Ill.

National Biscuit Co., Marsielles, Ill.
National Fruit Co., Winchester, Va.
Neenah Paper Co., Neenah, Wis.
N. Y. & Penn. Paper Co., Lock Haven, Pa.

Olympic Forest Prod. Co., Port Angeles, Wash.
Ontario Paper Co., Thorold, Ont.
Owens-Illinois Glass Co., Streator, Ill.

Peavey Paper Prod. Co., Ladysmith, Wis.
Pennick & Ford Co., Cedar Rapids, Ia.
Pet Milk Co., Delta, O.
P. R. Mallory & Co., Indianapolis, Ind.
Procter & Gamble Co., Ivorydale, O.
Pullman St. Car & Mfg. Co., Butler, Pa.
Pullman St. Car & Mfg. Co., Mich. City, Ind.
Punxsutawney Beef & Prov. Co., Punxsutawney, Pa.

Quaker State Oil Ref. Corp., Farmers Valley, Pa.

Ranier Pulp & Paper Co., Shelton, Wash.
R.C.A. Mfg. Co., Camden, N. J.
Riegel Paper Corp., Milford, N. J.
Robertson Bleachery & Dye Works, New Milford, Conn.

Sanford Mills Inc., Sanford, Me.
Shell Oil Co., Dominguez, Cal.
Shell Oil Co., Martinez, Cal.
Shell Petroleum Corp., Tenn.
Sidney Blumenthal Co., Shelton, Conn.
Southbridge Finishing Co., Southbridge, Mass.
South Coast Corp., Mathews, La.
Southern Kraft Corp., Georgetown, S. C.
Spencer Kellogg Co., Edgewater, N. J.
Standard Oil Co. of N. J., Bayway, N. J.
Stanley Hiller, Ltd., San Francisco, Cal.
St. Joe Paper Co., St. Joe, Fla.
Sutherland Paper Co., Kalamazoo, Mich.

Taggart Oswego Paper & Bag Co., Oswego, N. Y.
Tasty Baking Co., Phila., Pa.
Tietjen & Lang Drydock Co., Hoboken, N. J.
Tonawanda Boxboards Inc., Tonawanda, N. Y.
Trenton Valley Distil. Corp., Trenton, Mich.
Tuthill Bldg. Mat Co., Chicago, Ill.

Union Stockyards & Trans. Co., Chicago, Ill.
U. S. Industrial Alcohol Co., Newark, N. J.
Utah Idaho Sugar Co., Toppenish, Wash.

Victor Brewing Co., Jeannette, Pa.
Vincennes Packing Co., Washington, Ind.
Viscose Co., Parkersburgh, W. Va.

Western Ice & Utilities Co., Anthony, Kan.
Westfield Acres Housing Project, Camden
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Westvaco Chlorine Co., S. Charleston, W. Va.
W. G. Sutton Co., Minonk, Ill.
Wilkes-Barre Lace Co., Wilkes-Barre, Pa.
Winchester Repeating Arms Co., New Haven, Conn.
Western Cartridge Co., Alton, Ill.
Winsted Hosiery Co., Winsted, Conn.
Wm. Pinchbeck Co., Guilford, Conn.

Zwicker Knitting Mills, Appleton, Wis.

INSTITUTIONAL PLANTS

A. & M. College of Texas, College Sta., Tex.
Allegheny County Home, Woodville, Pa.
Athens State Hospital, Athens, O.
Brethren Publishing Co., Elgin, Ill.
Chicago State Hospital, Dunning, Ill.
Colorado State Penitentiary, Cannon City, Col.
David Rankin School, St. Louis, Mo.
Fairfield State Hospital, Newtown, Conn.
General Motors Corp., Detroit, Mich.
Illinois Soldiers & Sailors Home, Quincy, Ill.
Illinois State Hospital, Manteno, Ill.
Indiana State Hospital, Logansport, Ind.
Junior High School, Philadelphia, Pa.
Kankakee State Hospital, Kankakee, Ill.
Kings County Hospital, New York, N. Y.
Lincoln Hospital, New York, N. Y.
Louisiana State Normal Col., Natchitoches, La.
Louisiana State University, Baton Rouge, La.
Massillon State Hospital, Massillon, O.
Metropolitan Hospital, New York, N. Y.
Minnesota State Soldiers Home, Minneapol's
Missouri State Hosp. No. 2, Farmington, Mo.
Missouri State School, Marshall, Mo.
Monson State Hospital, Monson, Mass.
New York, City of, Division of Hospitals, Welfare Island, N. Y.
North Carolina State College, Raleigh, N. C.
North East High School, Philadelphia, Pa.
Obear Nestor Glass Co., East St. Louis, Ill.
Penn Industrial School, Huntingdon, Pa.
Physical Culture Hotel, Dansville, N. Y.
Pittsburgh, City of, Dept. of Hospitals, Mayview, Pa.
Rome State School, Rome, N. Y.
State Hospital No. 4, Farmington, Mo.
State Hospital No. 1, Fulton, Mo.
State of Ill. School for Deaf, Jacksonville, Ill.
State Tuberc. Sanitarium, San Haven, N. D.
Texas Technical College, Lubbock, Tex.
University of Maryland, College Pk., Md.
University of Tennessee, Knoxville, Tenn.
University of West Va., Morgantown, W. Va.
U. S. Penitentiary, Atlanta, Ga.
Vassar College, Poughkeepsie, N. Y.
West Suburban Hospital, Oak Park, Ill.
Worcester State Hospital, Worcester, Mass.

INDUSTRIAL POWER PL

Name of Company and Location	Kind of Industry	Consulting Engineers	New, Addition or Replacement	First Operation, New Units	BOILERS						SUPER-HEATER		FURNACE		
					Number	Straight or Bent Tube	Max. Cap. Each, 1,000 Lb. Per Hr.	Gage Pressure, Lb. Per Sq. In.	Steam Temp., Deg. F.	Heating Surface, 1,000 Sq. Ft., Each	Heating Surface, 1,000 Sq. Ft.	Control	Waterwall Surface, 1,000 Sq. Ft.	Volume, 1,000 Cu. Ft.	Bottom, Dry or Slag Tap
700 lb. per sq. in. and upwards															
Ford Motor Co., Dearborn, Mich...	Automobile	Ford Motor Co.	Add	1936	1	B	900	1,350	910	30.0	21.9	B.P.	9.5	30.0	Dry
Firestone Tire & Rubber Co., Akron, O.	Rubber	Stone & Webster	Add	1935		S	300	1,300	760	11.8	4.0	....	7.6	14.5	Slag
Dow Chemical Co., Midland, Mich.	Chemical		Add	1936	1										
			Add	1937	1	B	300	1,250	850	3.5	4.9	B.P.	4.9	15.2	Slag
Pittsburgh Plate Glass Co., Barberton, O.	Chemical	C. W. E. Clarke	Add	1936	1	B	180	900	750	15.1	5.4	....	1.8	9.2	.....
Pittsburgh Plate Glass Co., Barberton, O.	Chemical	C. W. E. Clarke	Add	1937	1	B	225	900	750	15.1	5.4	....	2.4	9.2	.....
Ford Motor Co., Windsor, Ont.	Automobile		Add	1936	3	B	200	900	820	9.0	....	B.P.	4.3	....	Dry
Weirton Steel Co., Weirton, W. Va.	Steel		Add	1936	2	B	400	850	820	20.5	....	....	4.0	17.3	Slag
Eastman Kodak Co., Rochester, N. Y.	Photographic		New	....	1	B	200	825	750	13.7	....	....	1.4	8.2	.....
Industrial Rayon Corp., Painesville O.	Rayon		New	1938	3	B	90	725	780	8.7	....	B.P.	1.9	....	Dry
Gulf Oil Corp., Port Arthur, Tex.	Oil	Gulf Oil Corp.	Add	1936	2	B	225	725	680	15.7	2.0	....	2.3	7.3	.....
Monsanto Chemical Co., Monsanto, Ill.	Chemical	Stone & Webster	Add	1937	2	B	100	725	700	10.4	1.3	....	0.9	4.1	.....
Hammermill Paper Co., Erie, Pa.	Paper	Stone & Webster	Add	1936	2	B	80	725	775	8.9	....	....	....	....	Dry
Hercules Powder Co., Wilmington, Del.	Chemical		....	....	1	B	145	700	750	12.5	....	....	2.04	....	.....
General Foods Corp., Battle Creek, Mich.	Cereal	Stone & Webster	Add	1936	1	B	100	700	720	10.8	....	....	1.6	4.9	Dry
500—699 lb. per sq. in.															
Humble Oil & Refining Co., Baytown, Tex.	Oil	G. Walmsley	Add	1937	1	B	350	675	740	20.3	4.2	....	9.7	19.0	.....
Wheeling Steel Corp., Portsmouth, O.	Steel	C. W. E. Clarke	Add	1937	1	B	100	660	650	10.9	....	....	2.3	5.2	Dry
Johns Manville Co., Manville, N. J.	Insulation	Stone & Webster	Add	1937	1	B	125	660	645	....	....	....	....	....	Dry
Tennessee Eastman Corp., Kingsport, Tenn.	Chemical		....	....	2	..	135	650	700	11.4	....	....	1.2	5.4	.....
Chrysler Corp., Dodge Div., Detroit, Mich.	Automobile	Thos. E. Murray	Add	1937	1	B	140	650	725	9.2	....	....	3.0	7.6	Dry
Scott Paper Co., Chester, Pa.	Paper	Stone & Webster	Add	1937	1	B	125	630	750	13.2	2.0	Des.	....	4.2	.....
Cleveland Worsted Mills Co., Cleveland, O.	Textile		....	....	1	..	120	616	500	7.7	....	....	1.8	5.3	.....
Port Huron Sulphite & Paper Co., Port Huron, Mich.	Paper		Add	1938	1	B	90	615	710	7.9	0.95	....	1.9	4.5	Dry
Glen Alden Coal Co., Ashley, Pa.	Coal		....	....	4	..	48.5	600	635	6.1	....	....	0.13	2.4	.....
West Virginia Pulp & Paper Co., Luke, Md.	Paper	G. R. Wadleigh	Add	1937	1	B	350	580	720	20.5	3.2	....	12.0	19.6	Slag
West Virginia Pulp & Paper Co., Charleston, S. C.	Paper	G. R. Wadleigh	New	1937	2	B	225	570	720	11.4	....	....	6.5	12.0	Dry
Carnegie-Illinois Steel Corp., Chicago, Ill.	Steel	Un. Eng. & Cons., Inc.	New	1937	3	B	375	550	760	22.0	6.5	B.P.	5.8	17.2	.....
E. I. DuPont de Nemours Co., Buffalo, N. Y.	Chemical		Add	1937	1	B	120	550	750	10.2	....	....	2.2	6.7	Slag
West Virginia Pulp & Paper Co., Williamsburg, Pa.	Paper	G. R. Wadleigh	New	1936	2	B	100	550	700	7.4	0.6	....	3.2	6.2	Dry
Carnegie-Illinois Steel Corp., Youngstown, O.	Steel		....	....	2	..	150	525	690	17.7	....	....	2.5	11.3	.....
Ohio Boxboard Co., Rittman, O.	Paper	H. M. Wilson Co.	....	....	1	B	120	500	610	12.5	....	Des.	1.1	4.5	.....
400—499 lb. per sq. in.															
Hersney Chocolate Co., Hershey, Pa.	Chocolate		Add	1936	1	B	170	475	650	11.7	1.3	....	1.9	7.2	Dry
Jones & Laughlin Steel Co., Pittsburgh, Pa.	Steel		....	....	1	..	400	475	725	....	....	....	4.1	18.5	.....
McWilliams Dredging Co., Chicago, Ill.			....	1936	1	..	60	475	750	9.5	....	....	....	0.96	.....
Godchaux Sugars Inc., Reserve, La.	Sugar	E. L. Dennis	Add	1937	1	B	100	475	560	9.2	0.6	....	1.1	4.2	.....
MacAndrews & Forbes Co., Camden, N. J.		Wood & Kirkpatrick	Add	1937	2	B	100	465	650	7.3	....	....	1.8	5.1	Dry
Shell Petroleum Corp., Houston, Tex.	Oil		Add	1937	2	B	120	460	660	10.1	....	....	2.3	6.2	Dry
Sanford Mills, Inc., Sanford, Me.	Textile	J. A. Stevens, Inc.	Add	1937	1	..	55	460	620	6.1	....	....	....	2.5	.....
Hellwig Silk Dyeing Co., Philadelphia, Pa.	Dye	J. G. Berger	....	1937	1	..	114	450	....	11.8	....	....	2.2	5.4	.....
J. K. Mosser Leather Co., Williamsport, Pa.	Leather		....	1936	1	..	70	450	570	6.7	....	....	0.3	2.3	.....
American Smelting & Ref. Co., Perth Amboy, N. J.	Metal	B. J. Di Santo	New	1937	3	B	60	450	750	6.3	....	....	1.2	3.5	Dry
Buick Motor Co., Flint, Mich.	Automobile		Add	1936	4	B	150	450	510	12.1	0.6	....	1.7	6.1	Dry
Byron Weston Co., Dalton, Mass.	Paper	H. H. Fales	Add	1937	1		45	450	600	4.5	....	....	....	1.7	Dry
Celanese Corp. of America, Cumberland, Md.	Textile	S. B. Roberts	Add	1937	1	B	200	450	710	15.4	2.2	....	5.6	9.5	Dry
Carnegie-Illinois Steel Co., Chicago, Ill.	Steel		Add	....	3	..	300	450	750	....	....	....	....	....	.....
E. I. DuPont de Nemours & Co., Belle, W. Va.	Chemical		New	1937	2	..	75	450	625	6.1	....	....	2.2	3.8	.....
E. I. DuPont de Nemours & Co., Ampthill, Va.	Chemical		....	....	1	..	120	450	716	9.5	....	....	2.8	8.0	.....
New Haven Pulp & Board Co., New Haven, Conn.	Paper Board	F. L. Smith	Add	1937	1	B	135	450	650	9.8	1.5	....	....	6.0	.....
Lanett Bleachery & Dye Wks., Lanette, Ala.	Dye		....	....	1	..	60	450	580	7.3	....	....	....	3.4	.....
Niagara Alkali Co., Niagara Falls, N. Y.	Chemical	Jenks & Ballou	New	1936	2	B	64.9	450	Sat.	6.2	....	....	....	2.5	Dry
Libbey-Owens Ford Glass Co., Rossford, O.	Glass	Stone & Webster	Add	1937	1	B	175	450	775	6.7	2.4	....	3.1	6.5	.....
Pan American Refining Corp., Texas City, Tex.	Oil		Add	1937	2	B	104	450	708	13.6	....	....	....	6.0	.....
Sylvania Industrial Corp., Fredericksburg, Va.	Cellophane		Add	1937	1	B	60	450	600	6.4	0.9	....	0.4	2.0	.....
Union Bag & Paper Co, Savannah, Ga.	Paper	G. F. Hardy	....	1936	3	B	43.8	450	735	4.8	....	....	....	....	.....
Union Bag & Paper Co., Savannah, Ga.	Paper	G. F. Hardy	....	1936	3	B	33.7	450	735	3.4	....	....	....	....	.....
Union Bag & Paper Co., Savannah, Ga.	Paper	G. F. Hardy	....	1937	2	..	50	450	735	5.3	....	....	....	....	.....
Union Bag & Paper Co., Savannah, Ga.	Paper	G. F. Hardy	....	1937	2	..	75	450	735	8.3	....	....	....	....	.....
Wilshire Oil Co., Santa Fe Springs, Cal.	Oil	R. M. Parsons Co.	New	1937	4	B	45	450	560	3.6	....	....	....	6.4	.....
Pioneer Flintkote Co., Vernon, Cal.			....	1936	1	..	50	450	....	4.5	....	....	....	....	.....
National Cash Register Co., Dayton, O.	Business Mach.		Add	1937	1	B	100	450	725	10	....	....	....	5.3	Dry
Inland Paper Board Co., Versailles, Conn.	Paper	K. A. Lefren	Add	1937	1	B	65	450	606	5.9	....	....	1.1	2.9	.....
Magnolia Petroleum Co., Beaumont, Tex.	Oil		....	....	1	..	200	450	675	13.3	....	....	1.7	8.4	.....
Morris Paper Mills, Morris, Ill.	Paper		Add	1937	1	..	100	450	550	10.4	....	Des.	....	....	Dry
Staley Mfg. Co., Decatur, Ill.			Add	1937	1	B	150	450	650	9.5	....	....	3.3	9.8	Dry
Chesapeake Camp Corp., Franklin, Va.	Paper	J. E. Sirrine & Co.	New	1937	3	B	120	450	675	13.7	....	....	....	6.6	Dry
Diamond Braiding Mills, Inc., Chicago Hts., Ill.	Textile & Wire		Add	1937	1	B	13	450	660	1.8	0.6	Des.	0.6	1.2	Dry
Canadian Kodak Co., Ltd., Toronto, Ontario.	Photographic		....	1936	1	S	65	450	600	5.9	....	....	1.1	....	.....
John Morrell & Co., Ottumwa, Ia.	Packer		New	1937	1	B	120	448	720	10.0	1.5	....	2.6	8.2	Dry
Owens Illinois Glass Co., Newark, O.	Glass	Arthur Nelson	Add	1936	2	..	30	448	750	4.0	....	Des.	1.7	2.2	Dry
Colgate Palm Olive Peet Co., Jersey City, N. J.	Soap	G. A. Anbro	Add	1936	1	B	80	448	600	7.7	0.7	Des.	....	2.8	.....
Rath Packing Co., Waterloo, Ia.	Packing		....	....	1	..	35	448	....	5.4	....	....	....	....	.....
Granite City Steel Co., Granite City, Ill.	Steel		Add	1936	3	..	120	435	640	7.8	0.9	....	2.2	4.9	Dry
Timken Roller Bearing Co., Columbus, O.	Bearings		Add	....	1	..	60	433	630	4.8	....	....	0.7	1.8	.....
Viscose Co., Marcus Hook, Pa.	Rayon	H. A. Kuljian Co.	New	1937	3	B	125	425	750	9.0	12.1	....	2.3	7.0	Dry
E. I. DuPont de Nemours & Co., Richmond, Va.	Rayon		....	....	4	..	120	425	713	9.5	....	....	2.3	8.0	Dry
Congoleum Nairn, Inc., Marcus Hook, Pa.	Floor Covering		Add	1936	1	B	35	425	....	4.4	....	....	0.7	1.7	Dry
M. Schaefer Brewing Co., Brooklyn, N. Y.	Beverage	Fred Ophuls	New	1937	2	..	50	425	600	4.2	....	....	....	1.7	.....
E. I. DuPont de Nemours & Co., Waynesboro, Va.	Chemical		Add	1937	1	B	120	425	715	9.5	....	....	3.2	7.8	Dry
Great Lakes Steel Corp., Ecorse, Mich.	Steel		New	1937	3	B	750	425	700	14.8	....	....	2.4	5.7	.....
Great Lakes Steel Corp., Ecorse, Mich.	Steel		Add	1938	1	B	750	425	700	10.1	....	....	2.4	5.8	.....
			Add	1938	1	B	750	425	700	9.8	....	....	1.2	5.6	.....
Union Pacific Coal Co., Rock Springs, Wyo.	Coal		....	1936	1	..	75	420	700	8.6	....	....	0.9	4.1	.....
					1	..	75	145	470	8.6	....	....	0.9	4.1	.....
U. S. Rubber Products Co., Detroit, Mich.	Rubber		Add	1936	1	..	110	420	600	8.7	....	....	2.8	6.0	Dry
Socony Vacuum Oil Co., Paulsboro, N. J.	Oil		Add	1936	..	..	....	....	....	....	....	....	....	....	.....
Beckett Paper Co., Hamilton, O.	Paper	Fosdick & Hilmer	New	1936	2	B	28.2	400	350	3.1	....	....	....	0.9	.....

VER PLANTS OVER 200 LB.—Units Since Jan. 1, 1936

FURNACE				ECONOMIZER			AIR HEATER			FORCED-DRAFT FAN				INDUCED-DRAFT FAN						FUEL				
Waterwall Surface, 1,000 Sq. Ft.	Volume, 1,000 Cu. Ft.	Bottom, Dry or Slag Tap	1,000 B.t.u. Lb. Max., Per Cu. Ft. Per Hr.	Heating Surface, 1,000 Sq. Ft.	Gas Temperature Leaving, Deg. F.	Feedwater Temperature Entering, Deg. F.	Heating Surface, 1,000 Sq. Ft.	Air Temperature Leaving, Deg. F.	Gas Temperature Leaving, Deg. F.	Number Per Boiler	Capacity Each, 1,000 C.F.M.	Drive	Control	Number Per Boiler	Capacity Each, 1,000 C.F.M.	Drive	Control	Percent Makeup	Type of Firing Equipment	1,000 B.t.u. Per Lb.	Average, % Volatile	Average, % Ash	Average Ash-Fusing Temperature, Deg. F.	Flyash Precipitator
9.5	30.0	Dry	34.0	25.3	625	395	86.0	452	365	4	70.0	M.	VA.	2	260.0	M.	VA.	1	P.C.	14.4	31.3	6.4	2,700	..
7.6	14.5	Slag	24.1	8.1	680		23.1	444	410	1	103.0	M.	D.	1	183.0	M.	D.	....	P.C.	12.7	31	12	2,200	..
4.9	15.2	Slag	27.0	27.8	460	220	49.9	365	250	2	55.0	M.	V.S.	2	85.0	M.	V.S.	1	P.C.	13.5	35	7.5	2,250	..
1.8	9.2	.....	27.2	8.3	450	300	....	....	....	1	70.0	T.	V.S.	1	120.0	T.	V.S.	80	U.S.	12.7	40	10	2,100	..
2.4	9.2	.....	34.7	4.0	560	300	14.8	300	400	1	95.0	T.	V.S.	1	163.0	T.	V.S.	80	U.S.W.	12.7	40	10	2,100	..
4.3	....	Dry	....	4.2	535	375	9.9	340	330	1	....	M.	H.C.	1	....	M.	H.C.-VA.	12	P.C.	14.2	36	3.5	.....	..
4.0	17.3	Slag	31.0	....	....	....	49.5	....	....	1	113.0	T.	.....	1	228.0	T.	.....	....	P.C.-Gas	12.6	39.7	11.3	2,110	..
1.4	8.2	.....	33.9	3.2	488	320	9.0	250	352	2	63.0	M.-T.	.....	1	130.0	M.-T.	.....	20	Gas-Oil	....	....	....	.....	..
1.9	....	Dry	....	....	....	....	10.6	492	362	1	27.6	M.-T.	VA.	1	51.0	M.-T.	VA.	....	P.C.	12.3	33.0	11.7	2,200	..
2.3	7.3	.....	35.8	....	....	....	25.8	495	383	1	56.0	M.-T.	D.	1	99.0	M.-T.	D.	22.4	Gas-Oil	....	....	....	.....	..
0.9	4.1	.....	32.6	1.8	556	300	6.8	270	398	1	40.0	M.	VA.	1	50.0	T.	V.S.	60	C.G.S.	9.8	33.7	15.7	1,950	..
....	....	Dry	28.0	....	....	....	9.5	550	425	1	30.0	M.	VA.	1	40.0	M.	VA.	60	P.C.	13.6	34	9	2,200	..
2.04	....	.....	....	6.8	....	....	....	....	....	1	59.0	.....	.....	1	89.0	....	.....	....	U.S.	....	....	....	.....	..
1.6	4.9	Dry	25.2	....	....	340	9.5	512	351	1	32.0	T.	D.-VS.	1	62.0	T.	D.-V.S.	35	P.C.	10.6	32.4	10.4	2,110	CY.
9.7	19.0	.....	24.3	13.5	525	350	....	....	....	1	89.0	M.-T.	VA.	2	107.8	M.T.	VA.	....	Oil-A.S.	18.6	....	....	.....	..
2.3	5.2	Dry	25.4	....	....	....	8.5	....	....	1	33.6	M.	VA.	1	57.3	M.	VA.	90	P.C.	13.7	33.7	6.8	2,200	..
....	....	Dry	....	....	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	60	P.C.-Oil	14.5	....	....	.....	..
1.2	5.4	.....	30.4	3.0	....	....	7.3	....	....	1	44.0	.....	.....	1	75.0	....	.....	....	U.S.	14.6	....	....	.....	..
3.0	7.6	Dry	22.4	....	....	....	12.9	470	339	1	49.3	T.	V.S.	1	103.8	T.	V.S.	....	P.C.	13.6	34.5	8.4	2,300	..
....	4.2	.....	26.3	....	....	....	8.7	520	410	1	40.0	M.	D.	1	100.0	M.	D.	12	Oil	....	....	....	.....	..
1.8	5.3	.....	....	....	....	....	12.0	....	....	1	35.0	.....	.....	1	76.0	....	.....	....	P.C.	....	....	....	.....	..
1.9	4.5	Dry	24.7	....	....	....	14.0	530	347	1	23.4	M.	VA.	1	60.0	M.	V.S.	30	P.C.	13.8	36.0	6.3	2,710	..
0.13	2.4	.....	....	....	....	....	....	....	....	1	30	.....	.....	..	....	....	.....	....	C.G.S.	....	....	....	.....	..
12.0	19.6	Slag	25.0	5.0	585	212	28.0	340	405	1	122.0	T.	V.S.	1	241.0	T.	V.S.	40	P.C.	13.0	15.6	14.6	2,500	..
6.5	12.0	Dry	26.3	....	....	....	34.0	560	410	1	66.5	M.	V.S.-VA.	1	105.0	M.	V.S.-VA.	40	P.C.-Oil	14.2	20.3	4.5	2,500	W.
5.8	17.2	.....	31.0	7.2	705	289	26.2	550	530	2	45.0	M.-T.	D.	2	160.0	M.T.	D.	....	Oil	....	....	....	.....	..
2.2	6.7	Slag	25.2	....	....	....	9.6	382	447	1	33.0	T.	D.-V.S.	1	68.0	T.	V.S.	50	P.C.	13.3	37	5.8	2,250	..
3.2	6.2	Dry	16.7	....	....	....	5.5	420	470	1	36.0	M.	VA.	1	70.0	M.	D.-VA.	40	P.C.	13.7	24.3	6	2,300	W.
2.5	11.3	.....	....	1.4	....	....	15.4	....	....	1	65.0	.....	.....	1	200.0	....	.....	....	P.C.	....	....	....	.....	..
1.1	4.5	.....	34.8	5.1	450	320	....	....	....	1	55.0	T.	V.S.	1	110.0	M.	V.S.	35	C.G.S.	12.8	32	11	2,200	..
1.9	7.2	Dry	26.0	....	....	....	21.1	475	360	1	51.0	M.	.....	1	90.0	M.	H.C.	6	P.C.	14.0	32.2	7.5	2,700	F.
4.1	18.5	.....	30.9	....	....	....	40.8	....	....	1	133.0	.....	.....	2	198.0	....	.....	....	P.C.	12.8	....	....	2,100	..
....	0.96	.....	....	....	....	....	7.2	....	....	..	....	.....	.....	1	30.6	....	.....	....	Oil	....	....	....	.....	..
1.1	4.2	.....	32.3	....	....	....	8.8	420	355	1	108.0	M.	VA.	1	118.0	M.	VA.	20	Gas-Oil	18.0	....	....	.....	..
1.8	5.1	Dry	23.7	....	....	254	8.2	415	435	1	34.2	M.	.....	1	60.0	M.	.....	60	P.C.	14.2	17	7.5	2,450	..
2.3	6.2	Dry	28.7	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	Gas-Oil	18.0	....	....	.....	..
....	2.5	.....	....	....	....	....	4.0	....	....	1	....	.....	.....	1	....	....	.....	....	Oil	....	....	....	.....	..
2.2	5.4	.....	27.6	....	....	220	....	....	....	1	....	.....	.....	..	....	....	.....	85	P.C.	13.5	33	8	2,400	..
0.3	2.3	.....	....	1.9	....	240	....	....	....	2	32.0	M.-T.	.....	2	30.0	M.-T.	.....	60	C.G.S.	12.5	6.0	12.0	2,975	CY.
1.2	3.5	Dry	20.0	....	....	....	4.6	350	378	1	19.3	M.	D.-V.S.	1	33.3	M.	D.-V.S.	0–50	Oil	18.6	....	....	.....	..
1.7	6.1	Dry	24.9	....	....	....	20.0	584	342	1	47.0	T.	.....	1	89.0	T.	.....	50	P.C.	....	....	....	.....	..
....	1.7	Dry	....	....	....	....	6.3	400	320	1	11.8	S.C.M.	VA.....	1	25.6	S.R.M.	.....	60	P.C.	14.4	18.5	5.1	2,500	..
5.6	9.5	Dry	25.5	....	....	....	18.6	455	415	1	67.0	M.	V.S.	1	125.0	M.	V.S.	....	P.C.	14.0	20	6	2,700	W.
....	....	.....	....	....	....	....	....	....	....	2	....	.....	.....	2	....	....	.....	....	Oil-Gas	....	....	....	.....	..
2.2	3.8	.....	....	....	....	....	6.4	....	....	1	25.0	.....	.....	1	42.5	....	.....	....	P.C.	....	....	....	.....	..
2.8	8.0	.....	....	0.6	....	....	13.0	....	....	2	24.2	.....	.....	1	81.0	....	.....	....	P.C.	14.1	....	....	2,295	..
....	6.0	.....	31.8	8.3	425	250	....	....	....	1	55.0	S.C.M.	D.-V.S.	1	104.0	S.C.M.	D.-V.S.	15	U.S.	14.7	17.6	5.3	.....	..
....	3.4	.....	....	6.1	....	....	....	....	....	1	17.6	.....	.....	1	90.7	....	.....	....	P.C.	....	....	....	.....	..
....	2.5	Dry	30.0	....	....	....	6.3	515	343	1	20.5	T.	D.-V.S.	1	38.0	T.	V.S.	25	P.C.	14.0	28	6	2,400	..
3.1	6.5	.....	35.0	....	....	....	10.1	305	420	1	65.0	M.	V.S.	1	111.0	M.	V.S.	....	U.S.W.	13.3	38.5	10.9	2,131	..
....	6.0	.....	25.0	....	....	....	7.2	360	285	1	35.0	M.	D.	1	59.2	M.	D.	40	Oil-Gas	....	....	....	.....	..
0.4	2.0	.....	....	1.9	467	220	0.9	....	....	5	28.8	M.-T.	V.S.	5	38.0	M.-T.	V.S.	50	U.S.	14.7	16.6	5	2,810	..
....	....	.....	....	....	....	....	2.2	....	....	1	13.5	.....	.....	1	24.0	....	.....	....	Ref.-Oil	....	....	....	.....	..
....	....	.....	....	2.7	....	....	4.0	....	....	1	16.5	.....	.....	1	30.0	....	.....	....	Liq.	....	....	....	.....	..
....	....	.....	....	....	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	....	.....	....	....	....	.....	..
....	....	.....	....	....	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	....	.....	....	....	....	.....	..
....	6.4	.....	1.00	2.0	390	220	....	....	....	..	....	.....	.....	1	30.0	T.	.....	....	Oil-Gas	....	....	....	.....	..
....	....	.....	....	....	....	....	....	....	....	1	19.0	.....	.....	..	....	....	.....	....	Oil-Gas	....	....	....	.....	..
....	5.3	Dry	30	5.6	395	220	....	....	....	2	16.0	M.	V.S.	2	55.0	M.	D.-V.S	30	P.C.	14.3	30	4.5	2,600	..
1.1	2.9	.....	....	....	....	....	3.9	330	387	1	14.2	M.	.....	1	28.0	M.	.....	40	Oil	....	....	....	.....	..
1.7	8.4	.....	33.4	....	....	240	16.1	505	375	1	65.7	T.	.....	1	125.0	T.	.....	75	N.G.-Oil	22.0	....	....	.....	..
....	....	Dry	....	....	325	220	....	....	....	1	....	T.	.....	1	....	M.	.....	15	T.G.S.	....	....	14.0	2,100	..
3.3	9.8	Dry	21.7	....	....	228	12.9	582	440	1	44.6	M.	D.	1	91.0	M.	H.C.	....	P.C.	9.8	32	16	1,900	..
....	6.6	Dry	....	....	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	...	Oil Wood....	18.0 5.9	...	....	.....	..
0.6	1.2	Dry	....	....	....	....	0.9	....	....	1	5.1	M.	V.S.	1	14.0	M.	D.	....	P.C.	....	....	....	.....	..
1.1	....	.....	....	1.9	....	....	....	....	....	1	21.0	M.-T.	.....	1	32.0	M.	.....	....	C.G.S	13.3	33	8	1,900	..
2.6	8.2	Dry	30.0	....	....	....	11.0	400	300	2	40.0	M.	D.	1	68.0	T.	D.-V.S.	70	P.C.	10.0	45	15	1,800	CY.
1.7	2.2	Dry	....	....	....	....	45.0	....	....	1	11.4	T.	V.S.	1	19.9	T.	V.S.	....	P.C.	....	....	....	.....	..
....	2.8	.....	38.0	3.0	425	230	....	....	....	1	30.0	T.	V.S.	1	50.0	T.	V.S.	80	T.G.S.	11.7	6	13	2,900	..
....	....	.....	....	....	....	....	....	....	....	1	20.0	.....	.....	..	....	....	.....	....	C.G.S.	....	....	....	.....	..
2.2	4.9	Dry	42.0	6.0	520	220	10.8	400	325	1	45.0	M.	.....	1	65.0	M.	.....	80	P.C.-N.G.	11.4	40	10	2,400	..
0.7	1.8	.....	45.2	3.1	379	210	....	....	....	1	25.0	S.C.M.	D.	1	30.0	S.C.M.	D.	....	U.S.	13.2	35	6.9	2,575	..
2.3	7.0	Dry	....	....	....	....	12.1	465	380	1	45.0	M.	H.C.	1	90.0	M.	H.C.	....	P.C.-Oil	18.9	....	....	.....	CY.
2.3	8.0	Dry	20.8	0.6	630	265	13.0	385	382	2	24.3	M.	V.S.-D.	1	81.0	M.	V.S.-D	4	P.C	14.1	17	5	2,450	..
0.7	1.7	Dry	24.7	....	....	....	4.2	350	370	1	10.8	.....	D.	1	18.8	....	D.	....	P.C.-Oil	13.7-18	....	....	.....	..
....	1.7	.....	27.5	3.3	....	288	....	....	....	1	14.1	.....	.....	1	26.8	....	.....	....	Oil	....	....	....	.....	..
3.2	7.8	Dry	20.3	0.6	628	300	13.0	383	381	2	24.3	M.	H.C.	1	81.0	M.	V.S.	40	P.C.	13.3	21.1	6.3	2,200	..
2.4	5.7	.....	19–17	....	....	....	6.2	500	473	1	29.0	T.	.....	1	80.0	T.	.....	....	Gas-Oil	....	....	....	.....	..
2.4	5.8	.....	19–27	....	....	....	8.0	485	500	1	17.6	T.	.....	1	33.4	T.	.....	....	Gas	....	....	....	.....	..
1.2	5.6	.....	19–27	1.9	500	210	8.0	390	400	1	21.7	T.	.....	1	32.4	T.	.....	....	Gas-St.	....	....	....	.....	..
0.9	4.1	.....	....	....	....	....	....	....	....	1	30.0	.....	.....	1	40.0	....	.....	....	P.C....	11.4	....	....	2,785	..
0.9	4.1	.....	....	....	....	....	....	....	....	1	30.0	.....	.....	1	40.0	....	.....	....	P.C.					
2.8	6.0	Dry	24.2	....	....	....	13.3	580	350	1	36.0	M.	D.	1	71.0	M.	D.	20	P.C.	13.2	34	6.5	2,650	..
....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	.....	....	....	....	.....	..
....	0.9	.....	35.0	....	....	....	....	....	....	..	....	T.	V.S.	..	....	....	.....	40	U.S.	14.4	30	5	2,750	..
....	....	.....	....	5.0	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	.....	....	....	....	.....	..

Average Ash-Fusing Temperature, Deg. F.	Flyash Precipitator	Average Boiler-Plant Efficiency, Per Cent	BOILER-FEED PUMPS			GENERATING UNITS									1,000
			Number	Capacity Each, G.P.M.	Head, Lb. Per Sq. In.	Power Unit, Type	Number	Top	Power Unit, Speed R.P.M.	Capacity Each, 1,000 KW.	Throttle Pressure, Lb. Per Sq. In. G	Throttle Temp., Deg. F.	Extraction Pressure, Lb. Per Sq. In. G	Exhaust Pressure, Lb. Per Sq. In. Abs.	Condenser Tube Area, Sq. Ft.
2,700	..	88	2	2,535	750	C.E.T.	1	No	1,800	110.0	1,215	910	—8–210	0.5	73.0
			2	2,800	1,600	B.P.T.	1	No	3,600	15.0	1,215	910	.....	255	.....
2,200	..	85	2	850	1,400	B.P.T.	1	No	3,600	10.0	....	750	.....	265	.....
2,250	..	89	2	850	1,600	C.E.T.	1	No	3,600	10.0	400	700	4–100	2	.....
						B.P.T.	1	Yes	3,600	7.5	1,250	825	.....	400	.....
2,100	..	84.0	2	400	1,050	B.E.T.	1	Yes	3,600	5.0	825	750	400	155	.....
2,100	..	82–84	2	550	1,050	B.E.T.	1	Yes	3,600	5.0	825	750	400	135	.....
.....	..	87	2	632	900	B.P.T.	1	....	3,600	5.0	800	800	.....	.....	.....
						C.E.T.	1	Yes	3,600	20.0	800	800	7–200	.....	.....
2,110	..	....	3	800	....	B.P.T.	1	Yes	.....	10.0	800	800	.....	230	.....
.....	..	82.6	3	500	1,000	B.P.T.	1	....	3,600	5.0	800	750	.....	150	.....
2,200	..	85	2	540	825	C.E.T.	3	No	3,600	5.0	650	750	15	1.0	2.8
			1	270											
.....	..	87	3	990	950	B.P.T.	2	No	3,600	4.0	650	670	.....	140	.....
1,950	..	82	2	383	332	.....	..	....	.....	.....	....	....	.....	.....	.....
2,200	..	85	3	250	900	B.P.T.	1	No	3,600	4.0	650	750	.....	165	.....
.....	..	....	2	365	800	B.P.T	1	....	3,600	2.0	650	750	.....	145	.....
2,110	CY.	84	2	340	750	B.E.T.	1	No	3,600	2.5	650	720	125	30	.....
.....	..	82	1	1,000	825	B.P.T.	1	....	3,600	7.5	600	725	.....	155	.....
2,200	..	....	2	300	720	B.P.T.	1	....	3,600	3.0	600	630	.....	175	.....
.....	..	....	3	125	....	B.P.T.	1	Yes	3,600	2.5	645	645	.....	215	.....
.....	..	....	3	450	....	B.P.T.	1	....	.....	6.0	....	....	.....	115	.....
2,300	..	85	3	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	89	2	350	760	B.P.T.	1	Yes	3,600	4.0	600	750	275	18	.....
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
2,710	..	86	2	180	765	B.E.T.	1	Yes	3,600	2.0	600	700	160	45	.....
.....	..	....	2	350	....	.....	..	....	.....	.....	....	....	.....	.....	.....
2,500	..	85.1	3	800	715	C.E.T.	1	No	3,600	5.0	550	700	160	1.0	6.0
2,500	W.	85.0	3	1,000	765	C. E. T.	1	....	3,600	6.0	....	....	35	1.0	8.0
						B.E.T.	1	No	3,600	6.0	550	700	150	50	.....
.....	..	82.5	3	750	590	C.E.T.	1	....	1,500	25.0	450	750	25–66	0.50	20.3
						T.B.	3	No	3,000	6.0	450	750	.....	0.50	4.0
2,250	..	84.9	2	300	715	B.P.T.	1	Yes	3,600	1.5	525	725	.....	150	.....
2,300	W.	83.0	3	300	735	B.P.T.	1	Yes	3,600	2.0	550	700	.....	165	.....
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
2,200	..	82	1	300	600	C.E.T.	1	No	3,600	3.75	425	615	20	.....	3.1
2,700	F.	85	3	550	530	C.E.T.	1	No	3,600	10.0	400	650	7–175	1.0	9.4
2,100	..	....	1	1,750	....	C.T.	1	....	.....	20.0	....	....	.....	.....	22
.....	..	....	1	125	....	C.T.	1	....	.....	3.5	....	....	.....	.....	.....
						C.T	1	....	.....	0.75	....	....	.....	.....	4.2
.....	..	82	2	245	530	B.P.T.	1	Yes	3,600	1.5	440	557	.....	155	.....
2,450	..	85.5	2	500	570	B.P.T.	2	No.	3,600	2.0	450	650	90	20	.....
.....	..	75	2	700	530	B.P.T.	2	....	3,600	2.5	450	660	.....	215	.....
.....	..	....	2	110	550	B.E.T.	1	....	3,600	1.5	450	620	75	12.5	.....
2,400	..	81.5	3	....	250	.....	..	....	.....	.....	....	....	.....	.....	.....
2,975	CY.	75.5	3	300	550	Eng.	3	....	.....	Tot.3.0	425	570	10–40	10-1.5	.....
			2			T.	2								
.....	..	83.5	3	120	500	C.E.T	2	....	3,750	1.5	400	700	150	1.0	1.9
.....	..	80	2	1,300	300	M.P.T.	1	No	3,600	3.0	160	420	5	1.5	.....
2,500	..	8.2	1	120	500	C.E.T.	1	No	6,000	1.3	430	580	12	1.25	.....
2,700	W.	86.5	1	500	525	B.E.T.	1	No	3,600	10.0	400	700	150	60	.....
.....	..	....	..	....	....	C.E.T.	1	....	.....	25.0	450	750	.....	1.25	.....
.....	..	....	..	....	....	B.E.T.	1	....	3,600	7.5	425	600	30–150	25	.....
2,295	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	82	1	360	580	B.E.T.	1	....	3,600	3.5	400	650	80	45	.....
.....	..	....	..	300	....	.....	..	....	.....	.....	....	....	.....	.....	.....
2,400	..	....	2	150	525	.....	..	....	.....	.....	....	....	.....	.....	.....
2,131	..	86	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	82.5	2	450	550	B.P.T.	1	....	3,600	3.0	415	700	.....	140	.....
2,810	..	82	1	250	250	B.P.T.	1	....	3,600	1.5	400	598	.....	75	.....
			2	150		B.P.T.	3	....	3,600	7.5	400	598	.....	60	.....
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	....	..	....	....	C.E.T.	1	....	3,600	7.0	400	750	35–130	.....	4.2
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	84	2	....	565	.....	..	....	.....	.....	....	....	30	.....	.....
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
2,600	..	84	2	300	525	C.E.T.	1	....	3,600	4.0	400	700	80	1.0	3.0
.....	..	....	2	200	550	B.P.T.	1	Yes	3,600	0.75	425	600	.....	165	.....
.....	..	81.3	..	....	....	C.E.T.	1	....	3,600	7.5	385	675	25–150	1.5	5.7
2,100	..	82	2	....	500	.....	1	....	4,500	0.50	450	550	.....	.....	1.0
1,900	..	....	2	400	550	B.E.T.	1	No	3,600	6.0	400	650	130	18	.....
.....	..	....	..	....	....	C.E.T.	1	....	3,600	3.5	400	675	60	1.0	.....
						B.E.T.	1	....	3,600	3.0	400	675	150	75	.....
.....	..	....	2	37	500	M.P.T	1	....	4,780	0.12	100–10	....	.....	1.5	0.3
						B.P.T.	1	No	3,634	0.25	425	650	100	25	.....
1,900	..	....	3	200	515	B.E.T.	1	....	8,000	0.75	425	590	150	19	.....
1,800	CY.	85.5	2	300	475	B.E.T	1	....	3,600	2.5	450	710	65–150	.....	.....
.....	..	....	2	100	....	B.P.T.	1	....	3,600	0.5	448	750	.....	200	.....
2,900	..	79	..	....	....	B.E.T.	1	....	3,600	1.5	400	600	85	19.7	.....
.....	..	....	2	160	....	B.P.T.	1	....	.....	0.62	....	....	125	.....	.....
2,400	..	81.0	2	750	500	C.E.T	2	No	3,600	7.5	400	620	160	1.5	8.0
2,575	..	86.0	2	120	550	C.E.T	1	No	3,600	1.5	400	630	145	1.0	3.5
.....	CY.	85	3	300	490	C.E.T.	3	....	3,000	3.0	....	....	175	.....	5.7
						C.E.T.	2	....	3,600	2.0	415	700	20	.....	3.6
2,450	..	....	1	800	500	C.E.T.	1	....	3,600	5.0	400	640	30	1.0	6.6
						B.P.T.	1	No	3,600	5.0	400	640	30	45	.....
.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	....	2	120	....	C.E.T.	2	....	4,500	0.50	425	600	50	.....	.....
2,200	..	85	..	....	....	B.E.T	1	No	3,600	3.0	425	700	180	90	.....
.....	..	....	3	350	550	C.T.	3	....	3,000	.....	400	700	.....	1.0	5.5
.....	..	80	..	....	....	C.T.	1	....	2,800	.....	400	700	.....	1.0	5.7
.....	..	84	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
2,785	..	....	2	200	....	C.E.T.	1	....	.....	5.0	....	....	5–65	.....	7.0
2,650	..	86.0	3	450	475	C.E.T.	1	No	3,600	5.0	400	600	160	1.5	6.5
.....	..	....	..	....	....	B.P.T	1	....	3,600	5.0	405	550	.....	215	.....
2,750	..	77	2	100	....	.....	..	....	.....	.....	....	....	.....	.....	.....
.....	..	....	1	650	....	C.E.T.	1	....	.....	7.5	....	....	.....	.....	8.2

Great Lakes Steel Corp., Ecorse, Mich.	Steel		New	1937	3	B	750	425	700	14.8	....	....	2.4	5.7	.....	19
Great Lakes Steel Corp., Ecorse, Mich.	Steel		Add	1938	1	B	750	425	700	10.1	....	....	2.4	5.8	.....	19
			Add	1938	1	B	750	425	700	9.8	....	....	1.2	5.6	.....	19
Union Pacific Coal Co., Rock Springs, Wyo.	Coal		....	1936	1	..	75	420	700	8.6	....	....	0.9	4.1	.....	..
					1	..	75	145	470	8.6	....	....	0.9	4.1	.....	..
U. S. Rubber Products Co., Detroit, Mich.	Rubber		Add	1936	1	..	110	420	600	8.7	....	....	2.8	6.0	Dry	24
Socony Vacuum Oil Co., Paulsboro, N. J.	Oil		Add	1936	..	..	....	....	....	....	....	....	....	....	.....	..
Beckett Paper Co., Hamilton, O.	Paper	Fosdick & Hilmer	New	1936	2	B	28.2	400	350	3.1	....	....	....	0.9	.....	33
Spring Cotton Mills, Lancaster, S. C.	Textile		....	1937	1	..	67.5	400	700	....	....	....	....	....	.....	..
Phelps Dodge Corp., Douglas, Ariz.	Copper	Mr. Legrand	....	1936	1	..	60	400	650	27.2	....	....	....	....	.....	..
Adolph Coors Co., Golden, Col.	Beverage		New	....	..	..	....	....	....	....	....	....	....	....	.....	..
Franklin Board & Paper Co., Franklin, O.	Paper		New	1936	1	B	40	400	650	7.4	....	....	....	2.2	.....	33
Champion Paper & Fiber Co., Canton, N. C.	Paper		....	....	..	..	....	....	....	....	....	....	....	....	.....	..
Below 300 lb. per sq. in.																
International Paper Co., Livermore Falls, Me.	Paper		Add	1937	..	..	....	....	....	....	....	....	....	....	.....	..
Standard Oil of Indiana, Whiting, Ind.	Oil		Add	1937	..	..	....	....	....	....	....	....	....	....	.....	..
R. J. Reynolds Tobacco Co., Winston-Salem, N. C.	Tobacco	J. E. Sirrine & Co.	Add	....	2	S	100	385	560	7.2	....	Des.	0.54	2.6	Dry	41
American Cyanamide & Chem. Co., Bridgeville, Pa.	Chemical		Add	1936	1	B	100	350	Sat.	9.3	....	....	....	4.5	Dry	28
American Enka Corp., Enka, N. C.	Rayon Yarn		Add	1937	2	B	75	350	700	8.2	....	....	4.0	4.2	Dry	24
Spreckel's Sugar Co., Woodland, Cal.	Sugar		....	1937	2	..	100	350	520	8.7	....	....	0.91	4.2	.....	..
Hartford City Paper Co., Hartford City, Ind.	Paper	A. M. Kinney, Inc.	New	1937	1	B	55	350	600	5.4	0.2	....	1.1	3.4	Dry	20
Dresden Paper Co., Dresden, O.	Paper	A. M. Kinney, Inc.	New	1936	1	B	45	335	500	6.5	....	....	0.07	1.9	Dry	31
Wolf River Paper & Fiber Co., Shawano, Wis.	Paper	W. G. Jonson	New	1936	1	..	34	325	550	4.0	....	....	....	3.3	Dry	..
Andrew Jergens Co., Cincinnati, O.	Soap, etc.	A. M. Kinney, Inc.	Add	1936	..	..	....	....	....	....	....	....	....	....	.....	..
American Can Co., Marwood, Ill.	Containers		Add	....	2	..	75	300	....	8.3	....	....	0.93	3.6	.....	..
Mead Johnson & Co., Evansville, Ind.	Baby Food		....	....	1	B	70	300	Sat.	6.3	....	....	....	....	.....	..
Savannah Sugar Ref. Co., Port Wentworth, Ga.	Sugar	A. M. Ormond	....	1937	..	..	....	....	....	....	....	....	....	....	.....	..
Wilson & Co., Albert Lee, Minn.	Meat		New	1937	3	B	90	290	525	4.9	....	....	1.3	4.1	Dry	24
Tubize Chatillon Corp., Rome, Ga.	Rayon		....	....	1	..	45	285	645	5.2	....	....	0.2	....	.....	..
Simplex Wire & Cable Co., Cambridge, Mass.	Ins. Wire	C. T. Main Co.	Add	1937	1	B	24	275	440	2.7	0.5	....	....	1.4	Dry	27
Guide Lamp Co., Anderson, Ind.	Lamp	H. B. Wilson	Add	1936	1	B	50	275	577	6.3	0.4	....	1.5	3.1	Dry	22
Southern Extract Co., Knoxville, Tenn.	Extracts		....	....	..	..	....	....	....	....	....	....	....	....	.....	..
Bemis Bros. Bag Co., Peoria, Ill.	Paper Bags	Mr. Merkle	....	1936	1	..	70	275	600	8.4	....	....	3.1	4.8	.....	20
Ebensburg Coal Co., Colver, Pa.	Coal	Loeb & Snaw, Inc.	Add	1936	3	B	45	250	500	5.5	....	....	4.1	2.0	Dry	29
General Aniline Co., Rensselaer, N. Y.	Dye	H. P. Angermueller	....	1937	1	..	80	250	471	8.5	0.3	....	1.8	3.9	Dry	26
United Refining Co., Warren, Pa.	Oil	C. W. E. Clarke	New	1937	2	B	55	250	Sat.	5.8	....	....	0.75	3.2	Dry	..
Collins & Aikman Co., Philadelphia, Pa.			....	1936	1	B	30.0	250	Sat.	....	....	....	....	....	.....	..
					1	B	45.0									
					1	B	55.0									
Stewart Warner Corp., Chicago, Ill.	Electric		....	....	3	..	36	250	Sat.	....	....	....	....	....	.....	..
Viscose Co., Roanoke, Va.	Rayon	H. A. Kuljian Co.	Add	1937	..	..	....	....	....	....	....	....	....	....	.....	..
Whippany Paper Bd. Co., Whippany, N. J.	Paper Board		....	....	1	..	66	250	....	7.5	....	....	0.54	4.2	.....	..
American Molasses Co., Brooklyn, N. Y.	Molasses		....	1936	2	..	35	250	550	4.4	....	....	0.48	1.7	.....	28
American Molasses Co., Brooklyn, N. Y.	Molasses		....	....	..	..	....	....	....	....	....	....	....	....	.....	..
Aluminum Co. of America, Pittsburgh, Pa.	Aluminum		....	1937	1	..	120	250	456	18.0	....	....	....	....	.....	..
Gonic Mfg. Co., Gonic, N. H.			....	....	1	..	35	250	500	4.4	....	....	....	6.3	.....	..
St. Regis Kraft Co., Tacoma, Wash.	Paper	Mr. Ferguson	Add	1936	1	B	65	250	433	8.3	....	....	1.0	4.4	.....	..
Servel Inc., Evansville, Ind.	Refrigerators		....	1936	2	..	50	250	....	6.9	....	....	....	1.9	.....	..
John Deere Tractor Co., Waterloo, Ia.	Tractor	Deere & Co.	Add	1937	1	S	45	236	488	6.8	....	....	1.0	1.1	.....	..
Van Brunt Mfg. Co., Horicon, Wis.			....	1936	1	..	21	236	....	3.2	....	....	....	....	.....	..
Dain Mfg. Co., Ottumwa, Ia.	Agr. Mach.	Deere & Co.	Add	1936	1	S	15	236	Sat.	....	....	....	....	0.5	.....	..
Kentucky Gas Transmission Corp., Boldman, Ky.	Nat. Gas Trans.		....	....	..	..	....	230	....	....	....	....	....	....	.....	..
Diamond Match Co., Oswego, N. Y.	Match		....	....	1	B	....	225-27	547	5.0	....	....	....	1.8	.....	..
Clearfield Bit. Coal Co., Indiana, Pa.	Coal		....	....	1	B	70	225	477	10.1	....	....	0.55	3.4	.....	..
Crowell Publishing Co., Springfield, O.	Publishing		....	....	1	..	125	225	600	12.7	6.0	....	0.66	4.8	.....	..
Firestone Tire & Rubber Co., Akron, O.	Rubber		New	1936	1	B	23	225	Sat.	4.8	....	....	....	1.5	Dry	10
Agar Mfg. Co., Chicago, Ill.			....	1936	1	..	....	225	....	2.4	....	....	....	....	.....	..
Heekin Can Co., Norwood, O.	Containers		....	1936	1	..	25	225	Sat.	3.5	....	....	....	0.90	.....	..
Shell Oil Co., San Francisco, Cal.	Oil		....	....	17	..	14	225	488	2.4	....	....	....	0.90	.....	..
Shell Oil Co., San Francisco, Cal.	Oil		....	....	1	..	54	210	488	6.9	....	....	0.14	3.1	.....	..

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700	14.8	....	....	2.4	5.7	.....	19–17	....	....	....	6.2	500	473	1	29.0	T.	.....	1	80.0	T.	.....	....	C
700	10.1	....	....	2.4	5.8	.....	19–27	....	....	....	8.0	485	500	1	17.6	T.	.....	1	33.4	T.	.....	....	C
700	9.8	....	....	1.2	5.6	.....	19–27	1.9	500	210	8.0	390	400	1	21.7	T.	.....	1	32.4	T.	.....	....	C
700	8.6	....	....	0.9	4.1	.....	....	....	....	....	....	....	....	1	30.0	.....	.....	1	40.0	....	.....	....	P
470	8.6	....	....	0.9	4.1	.....	....	....	....	....	....	....	....	1	30.0	.....	.....	1	40.0	....	.....	....	P
600	8.7	....	....	2.8	6.0	Dry	24.2	....	....	....	13.3	580	350	1	36.0	M.	D.	1	71.0	M.	D.	20	P
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	U
350	3.1	....	....	....	0.9	.....	35.0	....	....	....	....	....	....	..	....	T.	V.S.	..	....	....	.....	40	
700	....	....	....	....	....	.....	....	5.0	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
650	27.2	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	V
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
650	7.4	....	....	....	2.2	.....	35.0	....	....	....	....	....	....	1	....	T.	V.S.	..	....	....	.....	15	C
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
560	7.2	....	Des.	0.54	2.6	Dry	41.5	3.0	255	234	....	....	....	1	....	M.	D.	1	70.0	M.	V.S.	46	D
Sat.	9.3	....	....	....	4.5	Dry	28.8	....	....	....	....	....	....	1	25.0	M.-T.	VA.	1	74.0	M.-T.	.....	50	D
700	8.2	....	....	4.0	4.2	Dry	24.8	....	....	....	7.7	376	442	1	23.0	T.	V.S.	1	38.0	T.	V.S.	40	D
520	8.7	....	....	0.91	4.2	.....	....	....	....	....	5.1	....	....	1	35.0	.....	.....	1	55.6	....	.....	....	C
600	5.4	0.2	....	1.1	3.4	Dry	20.0	....	....	....	....	....	....	1	25.0	T.	.....	..	....	....	.....	20	D
500	6.5	....	....	0.07	1.9	Dry	31.0	....	....	....	....	....	....	1	20.0	T	V.S.	..	....	....	.....	....	V
550	4.0	....	....	....	3.3	Dry	....	....	....	200	2.0	....	....	1	....	.....	.....	1	....	M.	.....	....	D
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
....	8.3	....	....	0.93	3.6	.....	....	....	....	....	....	....	....	1	3.0	.....	.....	..	....	....	.....	....	C
Sat.	6.3	....	....	....	....	.....	....	....	....	230	....	....	....	1	....	M.	.....	..	....	....	.....	....	C
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
525	4.9	....	....	1.3	4.1	Dry	24.8	....	....	....	7.9	....	....	1	25.2	S.M.	H.C.	1	35.2	S.M.	H.C.	85	D
645	5.2	....	....	0.2	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	S
440	2.7	0.5	....	....	1.4	Dry	27.5	....	....	....	....	....	....	1	10.5	M.	V.S.	..	....	....	.....	30–50	C
577	6.3	0.4	....	1.5	3.1	Dry	22.4	....	....	....	3.5	360	380	1	16.2	T.	V.S.	1	28.5	T.	V.S.	75	D
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
600	8.4	....	....	3.1	4.8	.....	20.0	....	....	....	....	....	....	1	23.5	.....	.....	..	....	....	.....	....	D
500	5.5	....	....	4.1	2.0	Dry	29.3	....	....	....	4.1	338	446	1	60.0	M.-T.	.....	1	70.0	M.-T.	.....	6	D
471	8.5	0.3	....	1.8	3.9	Dry	26.0	....	....	....	5.7	330	385	1	26.0	M.	H.C.	1	32.0	M.	H.C.	....	D
Sat.	5.8	....	....	0.75	3.2	Dry	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	D
Sat.	....	....	....	....	....	.....	....	....	....	....	....	....	....	1	34.0	M.-T.	.....	..	....	....	.....	40	C
Sat'	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
....	7.5	....	....	0.54	4.2	.....	....	3.0	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	....	D
550	4.4	....	....	0.48	1.7	.....	28.8	....	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	....	D
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
456	18.0	....	....	....	....	.....	....	....	....	....	....	....	....	2	40.0	.....	.....	..	....	....	.....	....	S
500	4.4	....	....	....	6.3	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	C
433	8.3	....	....	1.0	4.4	.....	....	....	....	....	7.0	400	450	1	25.9	T.	.....	1	57.0	T.	.....	....	V
....	6.9	....	....	....	1.9	.....	....	....	....	....	....	....	....	1	16.8	.....	.....	..	....	....	.....	....	C
488	6.8	....	....	1.0	1.1	.....	....	....	....	....	....	....	....	1	21.2	T.	.....	1	120.0	T.	.....	15	D
....	3.2	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	S
Sat.	....	....	....	....	0.5	.....	....	....	....	....	....	....	....	1	10	M.	.....	..	....	....	.....	....	S
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	
547	5.0	....	....	....	1.8	.....	....	....	....	....	....	....	....	1	17.5	T.	V.S.	..	....	....	.....	12	D
477	10.1	....	....	0.55	3.4	.....	....	....	....	....	....	....	....	1	30.0	M.	D.-VA.	..	....	....	.....	....	S
600	12.7	6.0	....	0.66	4.8	.....	....	6.9	300	220	....	....	....	1	45.2	.....	.....	1	....	....	.....	20	D
Sat.	4.8	....	....	....	1.0	Dry	19.4	....	....	....	....	....	....	1	12?	..M.	VA.	..	....	....	.....	100	D

...	....	Gas-Oil	....	....	....	.....	..	....	3	350	550	C.T.	3	....	3,000	.....	400	700	.....	1.0	5.5
...	....	Gas	....	....	....	.....	..	80	..	....	....	C.T.	1	....	2,800	.....	400	700	.....	1.0	5.7
...	....	Gas-St.	....	....	....	.....	..	84	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	P.C....	11.4	....	....	2,785	..	....	2	200	....	C.E.T.	1	....	.....	5.0	....	....	5–65	.....	7.0
...	....	P.C.																			
...	20	P.C.	13.2	34	6.5	2,650	..	86.0	3	450	475	C.E.T.	1	No	3,600	5.0	400	600	160	1.5	6.5
...	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T	1	....	3,600	5.0	405	550	.....	215	.....
...	40	U.S.	14.4	30	5	2,750	..	77	2	100	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	.....	....	....	....	.....	..	....	1	650	....	C.E.T.	1	....	.....	7.5	....	....	.....	.....	8.2
												C.E.T.	1	....	.....	2.5	....	....	180	.....	2.6
												.....	2	....	.....	5.0	....	....	.....	.....	5.3
...	....	Waste Ht.	....	....	....	.....	..	....	..	....	....	C.E.T.	1	....	3,600	1.0	400	700	100	1.0	0.87
...	15	C.G.S.	10.5	32	6	2,800	..	75	2	125	425	C.E.T.	1	....	3,600	1.5	375	650	15–150	1.0	.75
...	....	.....	....	....	....	.....	..	....	..	....	....	B.E.T.	1	....	3,600	7.5	400	675	130	43.6	.....
...	....	.....	....	....	....	.....	..	....	..	....	....	C.E.T.	1	....	3,600	5.0	390	625	35	1.0	5.3
...	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T.	1	No	3,600	5.0	385	650	.....	110	.....
	46	U.S.	14.4	16.8	4	2,700	..	8.2	..	750	400	B.E.T.	1	....	3,600	7.5	355	560	150	25	.....
...	50	P.C.-Oil	13.2-18	33.9	9.8	2,100	..	....	2	310	247	.....	..	....	.....	.....	....	....	.....	.....	.....
	40	P.C	14.6	32.0	4.5	2,200	..	82.5	1	350	400	B.P.T.	1	....	3,600	1.0	325	700	.....	30	.....
												C.E.T.	1	....	3,600	3.0	325	700	20	1.0	3.2
...	....	Oil	....	....	....	.....	..	....	1	500	....	B.P.T.	1	....	.....	2.0	....	....	.....	55	.....
									2	300											
...	20	P.C.	11.3	34.4	11.0	2,100	..	79.5	2	200	1,100	C.T.	1	....	3,600	0.75	110	....	.....	1.5	.....
												B.P.T.	1	....	3,600	0.50	325	600	.....	110	.....
...	....	U.S.	13.0	39.4	11.0	2,160	..	73	2	150	....	B.P.T.	2	....	4,000	0.37	325	....	.....	25	.....
...	....	P.C.	14.0	35	4	2,800	..	80	2	100	....	B.P.T.	1	....	.....	0.50	325	530	.....	115	.....
...	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T.	1	No	3,600	0.40	310	490	.....	20	.....
...	....	Oil	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	C.G.S.	11.5	....	13	.....	..	....	2	225	....	B.E.T.	1	No	3,600	0.75	280	....	125	10	.....
...	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T.	1	....	3,600	2.0	300	620	.....	10	.....
	85	P.C.	10.8	....	....	1,900	F.	....	3	165	425	B.E.T.	1	....	.....	1.5	280	520	75–135	24	.....
													1	....	.....	1.0					
													1	Yes	3,600	0.5					
...	....	St.	....	....	....	.....	..	....	1	250	....	C.E.T.	1	....	3,600	3.0	285	617	15	1.25	.....
...	30–50	Oil	18.0	....	....	.....	..	76	2	40&25	225	.....	..	....	.....	.....	....	....	.....	.....	.....
	75	P.C.	11.6	33.8	8.9	2,400	..	85.8	2	150	313	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	.....	....	....	....	.....	..	....	2	300	300	C.E.T.	1	....	3,600	2.0	275	414	5–45	1.25	2.8
...	....	P.C.	....	....	....	.....	..	80	2	150	....	.....	..	....	.....	.....	....	....	.....	.....	3.2
...	6	P.C.	12.4	17	19	2,600	..	86	2	300	300	C.T.	1	No	1,800	5.0	225	500	.....	2	10.0
	....	P.C.	14.0	30	7	2,400	..	86	1	180	150	.....	..	....	.....	.....	....	....	.....	.....	.....
									1	400											
...	....	P.C.	13.0	31	11	2,100	..	80	2	240	300	.....	..	....	.....	.....	....	....	.....	.....	.....
...	40	Oil	15.0	....	....	.....	..	85	1	250	...	.....	1	....	.....	1.0	250	....	20	35	.....
									2	200											
...	....	.....	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	.....	....	....	....	.....	..	....	..	....	....	C.E.T.	1	....	3,600	3.0	250	550	15	1.0	8.0
...	....	P.C.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	P.C	....	....	....	.....	..	....	2	140	...	G.E.	1	....	.....	0.125	...	....	.....	27	.....
												B.P.T.	2	....	4,500	0.75					
...	....	.....	....	....	....	.....	..	....	..	....	....	.....	1	....	.....	1 0	....	....	.....	.....	.....
...	....	St.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	Oil-P.C.	....	....	....	.....	..	....	2	90	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	Wood-Oil	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	C.G.S.	....	....	....	.....	..	....	3	150	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	15	T.G.S.	....	....	....	.....	..	77	3	250	....	C.E.T.	1	....	.....	2.0	215	....	5	5	2.3
...	....	S.S	....	....	....	.....	..	....	..	....	....	Eng.	1	....	.....	0.35	....	....	.....	20	.....
...	....	S.S.	10.0	....	10	.....	..	70	2	40	155	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	.....	....	....	....	.....	..	....	..	....	....	Eng.	1	....	110	1 12	200	480	.....	2.0	.....
...	12	U.S.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
...	....	S.S.	12.5	28	12	2,200	..	....	2	220	200	C.E.T.	1	....	3,600	3 5	175	470	1–5	.....	11.0
												C.E.T.	2	....	3,600	1 0					
...	20	U.S.	14.5	30	4	2,700	..	....	2	275	....	Eng.	1	....	3,600	2 0	210	500	.....	.....	3.0
													4	....	275	0 5					
...	100	Ref	8.0	78	22	.....	..	68	2	50	250	.....	..	....	.....	.....	....	....	.....	.....	.....

700	14.8	....	....	2.4	5.7	.....	19–17	....	....	....	6.2	500	473	1	29.0	T.	.....	1	80.0	T.	.....	....	Ge
700	10.1	....	....	2.4	5.8	.....	19–27	....	....	....	8.0	485	500	1	17.6	T.	.....	1	33.4	T.	.....	....	Ga
700	9.8	....	....	1.2	5.6	.....	19–27	1.9	500	210	8.0	390	400	1	21.7	T.	.....	1	32.4	T.	.....	....	Ga
700	8.6	....	....	0.9	4.1	.....	....	....	....	....	....	....	....	1	30.0	.....	.....	1	40.0	....	.....	....	P.
470	8.6	....	....	0.9	4.1	.....	....	....	....	....	....	....	....	1	30.0	.....	.....	1	40.0	....	.....	....	P.
600	8.7	....	....	2.8	6.0	Dry	24.2	....	....	....	13.3	580	350	1	36.0	M.	D.	1	71.0	M.	D.	20	P.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
350	3.1	....	....	....	0.9	.....	35.0	....	....	....	....	....	....	..	....	T.	V.S.	..	....	....	.....	40	U.
700	....	....	....	....	....	.....	....	5.0	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
650	27.2	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	W.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
650	7.4	....	....	....	2.2	.....	35.0	....	....	....	....	....	....	1	....	T.	V.S.	..	....	....	.....	15	C.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
560	7.2	....	Des.	0.54	2.6	Dry	41.5	3.0	255	234	....	....	....	1	....	M.	D.	1	70.0	M.	V.S.	46	U.
Sat.	9.3	....	....	....	4.5	Dry	28.8	....	....	....	....	....	....	1	25.0	M.-T.	VA.	1	74.0	M.-T.	.....	50	P.
700	8.2	....	....	4.0	4.2	Dry	24.8	....	....	....	7.7	376	442	1	23.0	T.	V.S.	1	38.0	T.	V.S.	40	P.
520	8.7	....	....	0.91	4.2	.....	....	....	....	....	5.1	....	....	1	35.0	.....	.....	1	55.6	....	.....	....	Oi
600	5.4	0.2	....	1.1	3.4	Dry	20.0	....	....	....	....	....	....	1	25.0	T.	.....	..	....	....	.....	20	P.
500	6.5	....	....	0.07	1.9	Dry	31.0	....	....	....	....	....	....	1	20.0	T	V.S.	..	....	....	.....	....	U.
550	4.0	....	....	....	3.3	Dry	....	....	....	200	2.0	....	....	1	....	.....	.....	1	....	M.	.....	....	P.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
....	8.3	....	....	0.93	3.6	.....	....	....	....	....	....	....	....	1	3.0	.....	.....	..	....	....	.....	....	Oi
Sat.	6.3	....	....	....	....	.....	....	....	....	230	....	....	....	1	....	M.	.....	..	....	....	.....	....	C.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
525	4.9	....	....	1.3	4.1	Dry	24.8	....	....	....	7.9	....	....	1	25.2	S.M.	H.C.	1	35.2	S.M.	H.C.	85	P.
645	5.2	....	....	0.2	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	St
440	2.7	0.5	....	....	1.4	Dry	27.5	....	....	....	....	....	....	1	10.5	M.	V.S.	..	....	....	.....	30–50	Oi
577	6.3	0.4	....	1.5	3.1	Dry	22.4	....	....	....	3.5	360	380	1	16.2	T.	V.S.	1	28.5	T.	V.S.	75	P.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
600	8.4	....	....	3.1	4.8	.....	20.0	....	....	....	....	....	....	1	23.5	.....	.....	..	....	....	.....	....	P.
500	5.5	....	....	4.1	2.0	Dry	29.3	....	....	....	4.1	338	446	1	60.0	M.-T.	.....	1	70.0	M.-T.	.....	6	P.
471	8.5	0.3	....	1.8	3.9	Dry	26.0	....	....	....	5.7	330	385	1	26.0	M.	H.C.	1	32.0	M.	H.C.	....	P.
Sat.	5.8	....	....	0.75	3.2	Dry	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	P.
Sat.	....	....	....	....	....	.....	....	....	....	....	....	....	....	1	34.0	M.-T.	.....	..	....	....	.....	40	Oi
Sat'	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
....	7.5	....	....	0.54	4.2	.....	....	3.0	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	....	P.
550	4.4	....	....	0.48	1.7	.....	28.8	....	....	....	....	....	....	1	....	.....	.....	1	....	....	.....	....	P.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
456	18.0	....	....	....	....	.....	....	....	....	....	....	....	....	2	40.0	.....	.....	..	....	....	.....	....	St
500	4.4	....	....	....	6.3	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	Oi
433	8.3	....	....	1.0	4.4	.....	....	....	....	....	7.0	400	450	1	25.9	T.	.....	1	57.0	T.	.....	....	W.
....	6.9	....	....	....	1.9	.....	....	....	....	....	....	....	....	1	16.8	.....	.....	..	....	....	.....	....	C.
488	6.8	....	....	1.0	1.1	.....	....	....	....	....	....	....	....	1	21.2	T.	.....	1	120.0	T.	.....	15	T.
....	3.2	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	S.
Sat.	....	....	....	....	0.5	.....	....	....	....	....	....	....	....	1	10	M.	.....	..	....	....	.....	....	S.
....	....	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	..
547	5.0	....	....	....	1.8	.....	....	....	....	....	....	....	....	1	17.5	T.	V.S.	..	....	....	.....	12	U.
477	10.1	....	....	0.55	3.4	.....	....	....	....	....	....	....	....	1	30.0	M.	D.-VA.	..	....	....	.....	....	S.
600	12.7	6.0	....	0.66	4.8	.....	....	6.9	300	220	....	....	....	1	45.2	.....	.....	1	....	....	.....	20	U.
Sat.	4.8	....	....	....	1.5	Dry	16.7	....	....	....	....	....	....	1	150	I.M.	VA.	..	....	....	.....	100	R.
....	2.4	....	....	....	....	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	Oi
Sat.	3.5	....	....	....	0.90	.....	....	....	....	....	....	....	....	1	....	.....	.....	..	....	....	.....	....	U.
488	2.4	....	....	....	0.90	.....	....	....	....	....	....	....	....	..	....	.....	.....	..	....	....	.....	....	Oi
488	6.9	....	....	0.14	3.1	.....	....	....	....	....	....	....	....	2	8.0	.....	.....	..	....	....	.....	....	Oi

....	....	Gas-Oil	....	....	....	.....	..	....	3	350	550	C.T.	3	....	3,000	.....	400	700	.....	1.0	5.5
....	....	Gas	....	....	....	.....	..	80	..	....	....	C.T.	1	....	2,800	.....	400	700	.....	1.0	5.7
....	....	Gas-St.	....	....	....	.....	..	84	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
....	....	P.C....	11.4	....	....	2,785	..	....	2	200	....	C.E.T.	1	....	.....	5.0	....	....	5–65	.....	7.0
....	20	P.C.	13.2	34	6.5	2,650	..	86.0	3	450	475	C.E.T.	1	No	3,600	5.0	400	600	160	1.5	6.5
....	40	U.S.	14.4	30	5	2,750	..	77	2	100	....	B.P.T	1	....	3,600	5.0	405	550	.....	215	.....
....	....	.....	....	....	....	.....	..	....	1	650	....	C.E.T.	1	....	.....	7.5	....	....	.....	.....	8.2
												C.E.T.	1	....	.....	2.5	....	....	180	.....	2.6
												.....	2	....	.....	5.0	....	....	.....	.....	5.3
....	....	Waste Ht.	....	....	....	.....	..	....	..	....	....	C.E.T.	1	....	3,600	1.0	400	700	100	1.0	0.87
....	15	C.G.S.	10.5	32	6	2,800	..	75	2	125	425	C.E.T.	1	....	3,600	1.5	375	650	15–150	1.0	.75
....	....	.....	....	....	....	.....	..	....	..	....	....	B.E.T.	1	....	3,600	7.5	400	675	130	43.6	.....
....	....	.....	....	....	....	.....	..	....	..	....	....	C.E.T.	1	....	3,600	5.0	390	625	35	1.0	5.3
....	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T.	1	No	3,600	5.0	385	650	.....	110	.....
....	46	U.S.	14.4	16.8	4	2,700	..	8.2	..	750	400	B.E.T.	1	....	3,600	7.5	355	560	150	25	.....
..	50	P.C.-Oil	13.2-18	33.9	9.8	2,100	..	....	2	310	247	.....	..	....	.....	.....	....	....	.....	.....	.....
	40	P.C	14.6	32.0	4.5	2,200	..	82.5	1	350	400	B.P.T.	1	....	3,600	1.0	325	700	.....	30	.....
												C.E.T.	1	....	3,600	3.0	325	700	20	1.0	3.2
..	....	Oil	....	....	....	.....	..	....	1	500	....	B.P.T.	1	....	.....	2.0	....	....	.....	55	.....
									2	300											
..	20	P.C.	11.3	34.4	11.0	2,100	..	79.5	2	200	1,100	C.T.	1	....	3,600	0.75	110	....	.....	1.5	.....
												B.P.T.	1	....	3,600	0.50	325	600	.....	110	.....
..	....	U.S.	13.0	39.4	11.0	2,160	..	73	2	150	....	B.P.T.	2	....	4,000	0.37	325	....	.....	25	.....
..	....	P.C.	14.0	35	4	2,800	..	80	2	100	....	B.P.T.	1	....	.....	0.50	325	530	.....	115	.....
..	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T.	1	No	3,600	0.40	310	490	.....	20	.....
..	....	Oil	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	C.G.S.	11.5	....	13	.....	..	....	2	225	....	B.E.T.	1	No	3,600	0.75	280	....	125	10	.....
..	....	.....	....	....	....	.....	..	....	..	....	....	B.P.T.	1	....	3,600	2.0	300	620	.....	10	.....
	85	P.C.	10.8	....	....	1,900	F.	....	3	165	425	B.E.T.	1	....	.....	1.5	280	520	75–135	24	.....
													1	....	.....	1.0					
													1	Yes	3,600	0.5					
..	....	St.	....	....	....	.....	..	....	1	250	....	C.E.T.	1	....	3,600	3.0	285	617	15	1.25	.....
..	30–50	Oil	18.0	....	....	.....	..	76	2	40&25	225	.....	..	....	.....	.....	....	....	.....	.....	.....
	75	P.C.	11.6	33.8	8.9	2,400	..	85.8	2	150	313	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	.....	....	....	....	.....	..	....	2	300	300	C.E.T.	1	....	3,600	2.0	275	414	5–45	1.25	2.8
..	....	P.C.	....	....	....	.....	..	80	2	150	....	.....	..	....	.....	.....	....	....	.....	.....	3.2
..	6	P.C.	12.4	17	19	2,600	..	86	2	300	300	C.T.	1	No	1,800	5.0	225	500	.....	2	10.0
	....	P.C.	14.0	30	7	2,400	..	86	1	180	150	.....	..	....	.....	.....	....	....	.....	.....	.....
									1	400											
..	....	P.C.	13.0	31	11	2,100	..	80	2	240	300	.....	..	....	.....	.....	....	....	.....	.....	.....
..	40	Oil	15.0	....	....	.....	..	85	1	250	...	.....	1	....	.....	1.0	250	....	20	35	.....
									2	200											
..	....	.....	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	.....	....	....	....	.....	..	....	..	....	....	C.E.T.	1	....	3,600	3.0	250	550	15	1.0	8.0
..	....	P.C.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	P.C	....	....	....	.....	..	....	2	140	...	G.E.	1	....	.....	0.125	...	....	.....	27	.....
												B.P.T.	2	....	4,500	0.75					
..	....	.....	....	....	....	.....	..	....	..	....	....	.....	1	....	.....	1 0	....	....	.....	.....	.....
..	....	St.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	Oil-P.C.	....	....	....	.....	..	....	2	90	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	Wood-Oil	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	C.G.S.	....	....	....	.....	..	....	3	150	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	15	T.G.S.	....	....	....	.....	..	77	3	250	....	C.E.T.	1	....	.....	2.0	215	....	5	5	2.3
..	....	S.S.	....	....	....	.....	..	....	..	....	....	Eng.	1	....	.....	0.35	....	....	.....	20	.....
..	....	S.S.	10.0	....	10	.....	..	70	2	40	155	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	.....	....	....	....	.....	..	....	..	....	....	Eng.	1	....	110	1.12	200	480	.....	2.0	.....
..	12	U.S.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	S.S.	12.5	28	12	2,200	..	....	2	220	200	C.E.T.	1	....	3,600	3.5	175	470	1–5	.....	11.0
												C.E.T.	2	....	3,600	1.0					
..	20	U.S.	14.5	30	4	2,700	..	....	2	275	....	Eng.	1	....	3,600	2.0	210	500	.....	.....	3.0
													4	....	275	0.5					
..	100	Ref.	8.0	78	22	.....	..	68	2	50	250	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	Oil	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	U.S.	....	....	....	.....	..	....	..	....	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	Oil	....	....	....	.....	..	....	8	80	....	.....	..	....	.....	.....	....	....	.....	.....	.....
..	....	Oil	....	....	....	.....	..	....	1	420	....	.....	..	....	.....	.....	....	....	.....	.....	.....

For abbreviations, see over.

POWER

In Two Sections **Section Two**

Mid-September, 1937. Volume 81, Number 10

Publication Office, Albany, N. Y.
Editorial Office, New York, N. Y.

Name of Company and Location	Plant Name	Consulting Engineers	New, Addition or Replacement	First Operation, New Units	BOILERS						SUPER HEAT	
					Number	Straight- or Bent-Tube	Maximum Capacity Each 1,000 Lb. Per Hour	Gage Pressure, Lb. Per Sq. In.	Steam Temp., Deg. F.	Heating Surface, 1,000 Sq. Ft., Each	Heating Surface, 1,000 Sq. Ft.	
Indiana & Michigan Elec. Co., Mishawaka, Ind	Twin Branch	.....	....	....	1	..	....	2,500	940	....	....	
Ohio Power Co., Windsor, W. Va	Windsor	Amer. Gas & Elec. Co.	Add	1938	2	B	750	1,475	925	13.0	18.4	
Pub. Ser. Elec. & Gas Co., Newark, N. J	Essex	.....	Add	1938	2	B	605	1,475	950	3.1	15.4	
Columbus Ry. Pr. & Lt. Co., Groveport, O	Walnut	Un. L. & P. E. & Cons. Co.	Add	....	2	..	200	1,475	910	....	....	
Cincinnati Gas & Elec. Co., Cincinnati, O	West End	Sargent & Lundy	Add	1937	3	B	350	1,450	910	....	7.4	
West Penn Power Co., Sprigndale, Pa	Springdale	Sanderson & Porter	Add	....	3	S	575	1,450	935	6.2	....	
Appalachian Elec. Pr. Co., Logan, W. Va	Logan	Amer. Gas. & Elec. Co.	Add	1937	1	B	1,000	1,425	925	20.8	26.0	
Consolidated Edison Co., New York, N. Y	Waterside	.....	Add	1937	4	S	500	1,400	900	7.0	14.0	
Boston Edison Co., Boston, Mass	L Street	Jackson & Moreland	Add	1938	2	B	375	1,400	910	4.8	7.8	
Kansas City Pr. & Lt. Co., Kansas City, Mo	Northeast	Un. L. & P. E. & Cons. Co.	Add	1937	1	S	300	1,400	815	5.1	6.2	
Metropolitan Edison Co., Reading, Pa	West Reading	E. M. Gilbert Eng. Corp.	Add	1938	2	B	275	1,400	900	5.1	7.3	
Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis	Port Washington	.....	New	1935	1	B	690	1,390	840	44.1	10.1	
Philadelphia Elec. Co., Philadelphia, Pa	Schuylkill	.....	Add	1938	2	B	600	1,350	910	11.2	16.3	
Nebraska Power Co., Omaha, Neb	Omaha	Ebasco Services, Inc.	Add	1937	1	B	275	1,350	910	12.0	9.7	
Narragansett Elec. Co., Providence, R. I	.....	.....	Add	....	1	B	430	1,350	925	....	....	
Commonwealth Edison Co., Chicago, Ill	Fisk	Sargent & Lundy	Add	1937	2	S	375	1,275	910	6.6	19.8	
Dayton Pr. & Lt. Co., Dayton, O	Millers Ford	.....	Add	....	2	S	375	1,250	900	3.4	10.8	
West Penn Power Co., Windsor, W. Va	Windsor	.....	....	....	..	..	....	....	....	....	....	
Monongahela W. Penn Pub. Ser. Co., Fairmont, W. Va	Rivesville	Sanderson & Porter	Add	1937	2	S	362	1,240	915	4.9	....	
800–999 lb. per sq in.:												
Madison Gas & El. Co., Madison, Wis	Blount Street	Un. Lt. & P. E. & Con. Co.	Add	....	1	B	250	975	825	1.9	3.9	
Detroit Edison Co., Detroit, Mich	Delray	.....	Add	1938	3	B	424	950	910	8.2	9.4	
Williamsburg Pr. Plant Corp., Brooklyn, N. Y	Williamsburg	Stone & Webster	Add	1937	2	S	575	925	830	6.9	10.8	
Potomac Edison Co., Cumberland, Md	River	Sanderson & Porter	Add	1938	1	B	312	925	830	6.2	5.4	
Toledo Edison Co., Toledo, Ohio	Acme	.....	Add	....	1	..	253	900	825	....	....	
Consumers Power Co., Bay City, Mich	John C. Weadock	The C&S Corp., En. Cl. A.	New	1938	2	B	400	900	900	7.4	9.5	
Tampa Elec. Co., Tampa, Fla	W. Jackson Street	Stone & Webster	Add	1937	2	B	140	880	830	11.2	....	
New Orleans Public Service, Inc., New Orleans, La	Market Street	Ebasco Services, Inc.	Add	1938	1	B	385	875	905	20.8	9.3	
Gulf States Utilities Co., Beaumont, Tex	Neches River	Stone & Webster	Add	1937	1	B	320	875	915	10.0	0.9	
Hartford Elec. Lt. & Pr. Co., Hartford, Conn	So. Meadow	Stone & Webster	Add	1938	1	S	425	875	915	5.2	9.3	
Virginia Elec. & Pr. Co., Richmond, Va	Twelfth Street	Stone & Webster	Add	1936	1	B	450	860	835	24.8	8.7	
United Power Mfg. Co., Davenport, Ia	Riverside	Un. L. & P. E. & Con. Co.	Add	1937	1	B	300	860	825	8.0	6.4	
Tucson Gas Elec. Lt. & Pr. Co., Tucson, Ariz	.....	.....	Add	1937	1	B	75	825	825	6.5	....	
Central Illinois Lt. Co., Peoria, Ill	East Peoria	The C&S Corp., En. Cl. A.	Add	1938	1	B	300	800	850	14.7	....	
Georgia Power Co., Atlanta, Ga	Atkinson	.....	Add	....	2	..	400	800	850	....	....	
Consumers Power Co., Comstock, Mich	Bryce E. Morrow	The C&S Corp., En. Cl. A.	New	1938	1	B	400	800	850	7.4	9.5	
Consumers Power Co., Battle Creek, Mich	Elm Street	The C&S Corp., En. Cl. A.	Add	1937	1	S	360	800	850	4.1	....	
Ohio Edison Co., Springfield, O	Mad River	The C&S Corp., En. Cl. A.	Add	1938	1	B	225	800	850	6.2	7.2	
Southern Ind. Gas & Electric Co., Evansville, Ind	Ohio River	The C&S Corp., En. Cl. A.	Add	1938	1	B	225	800	850	5.3	6.8	
Penn Power Co., New Castle, Pa	New Castle	The C&S Corp., En. Cl. A.	New	1938	1	B	400	800	850	7.4	9.5	
500–799 lb. per sq. in.:												
Cincinnati Gas & Elec. Co., Cincinnati, O	Columbia	Sargent & Lundy	Add	1938	2	B	300	775	910	....	7.4	
Kansas Gas & Elec. Co., Wichita, Kan	.....	.....	....	....	..	..	160	725	835	....	....	
Milwaukee Electric Ry. & Lt. Co., Milwaukee, Wis	E. Wells Street	.....	Add	1938	1	B	225	725	825	13.5	5.6	
Potomac Elec. Pr. Co., Washington, D. C	Buzzard Point	.....	....	....	..	..	....	....	....	....	....	
Conn. Lt. & Pr. Co., Montville, Conn	.....	.....	Add	1937	2	B	130	725	825	9.1	....	
Virginia Pub. Ser. Co., Alexandria, W. Va	Alexandria	E. M. Gilbert Corp.	Add	1936	1	B	60	725	750	6.5	1.2	
New York State Electric & Gas Corp., Dresden, N. Y	Dresden	E. M. Gilbert Corp.	....	1937	2	..	110	725	825	8.8	....	
Keystone Pub. Ser. Co., Oil City, Pa	West End	E. M. Gilbert Corp.	Add	1936	1	B	100	725	750	10.8	1.0	
Penn Electric Co., Seward, Pa	Seward	E. M. Gilbert Corp.	Add	1937	2	B	200	725	825	16.3	....	
Hawaiian Electric Co., Honolulu, T. H	Pearl Harbor	.....	New	1938	1	..	90	700	825	9.0	....	
Indianapolis Power & Light Co., Indianapolis, Ind	.....	.....	Add	1938	2	B	350	683	786	20.1	7.5	
Iowa Electric Light & Power Co., Cedar Rapids, Ia	.....	.....	Add	1937	1	S	300	675	765	13.6	4.5	
Holyoke Water Pr. Co., Holyoke, Mass	Station No. 1	Arthur L. Nelson, Engrs.	Add	1936	1	B	200	675	750	10.5	....	
Duke Power Co., Mt. Holly, N. C	Riverbend	Duke Power Co.	Add	....	2	B	275	675	825	16.9	8.0	
Dallas Power & Light Co., Dallas, Texas	Mountain Creek	Ebasco Services, Inc.	New	1938	2	B	200	675	830	13.8	2.4	
Rochester Gas & Electric Co., Rochester, N. Y	Station No. 3	E. M. Gilbert Corp.	Add	1937	1	B	250	660	750	15.3	4.5	
Rochester Gas & Electric Co., Rochester, N. Y	Station No. 3	E. M. Gilbert Corp.	Add	1938	1	B	250	660	750	15.3	4.5	
Otter Tail Power Co., Fergus Falls, Minn	Wahpeton	.....	Add	1937	1	B	100	650	825	9.4	....	
Pacific Gas & Electric Co., Eureka, Cal	Station B	.....	Add	1936	1	..	50	650	750	5.2	....	
Public Service Co. of New Hampshire, Manchester, N. H	.....	.....	....	....	2	..	110	650	760	....	....	
United Illuminating Co., Bridgeport, Conn	Steel Point	Westcott & Mapes	Add	1937	2	B	125	615	850	11.1	2.8	
Detroit Edison Co., Detroit, Mich	Conners Creek	.....	Add	1936	5	B	420	600	850	26.8	9.4	
Iowa Public Service Co., Waterloo, Ia	Lafayette Street	.....	Add	1937	1	B	121	500	800	13.7	....	
400 to 499 lb. per sq. in.:												
Central Ohio Power & Light Co., Findlay, Ohio	Woodcock	Sargent & Lundy	....	1937	2	B	60	490	825	6.7	1.2	
Newport Elec. Corp., Newport, R. I	.....	Utilities Pr. & Lt. Op. Co.	....	1936	2	..	60	475	765	5.8	....	
Nebraska Power Co., Omaha, Neb	South Omaha	Ebasco Services, Inc.	New	1938	2	B	200	475	775	11.8	3.2	
Pacific Gas & Electric Co., Oakland, Cal	Station C	.....	Add	1938	2	B	220	475	725	17.6	....	
Duquesne Light Co., Pittsburgh, Pa	James H. Reed	Pub. Util. Eng. & Ser. Co.	Add	1938	2	B	350	475	760	30.6	9.8	
Northern States Power Co., Minneapolis, Minn	Riverside	Pub. Ut. Eng. & Ser. Co.	Add	1938	2	S	275	450	750	12.7	3.8	
Laclede Power & Light Co., St. Louis, Mo	.....	.....	Add	1936	1	S	210	450	795	13.5	3.8	
Public Service Company of Indiana, Terre Haute, Ind	Edwardsport	Sargent & Lundy	....	....	2	..	80	450	775	....	....	
					2	..	100	450	775	....	....	
Louisville Gas & Electric Co., Louisville, Ky	Canal	Pub. Ut. Eng. & Ser. Co.	Add	1937	1	S	350	450	750	9.4	6.2	
Fort Bend Utilities Co., Sugarland, Texas	.....	Arthur L. Nelson, Engrs.	New	1937	1	B	160	440	750	13.5	1.5	
Lynn Gas & Elec. Co., Lynn, Mass	.....	Stone & Webster	Add	1936	1	B	205	430	775	15.0	3.1	
Long Island Lighting Co., Glenwood, L. I., N. Y	Glenwood No. 2	L. I. Lighting Co.	Add	1938	..	..	....	....	....	....	....	
Philadelphia Electric Co., Philadelphia, Pa	Richmond	Un. L. & P. E & Cons. Co.	Add	1935	2	S	600	425	850	36.2	15.3	
Public Service Co. of Colorado, Denver, Colo	Valmont	.....	Add	1938	1	B	225	425	750	17.7	....	
Upper Michigan Power & Light Co., Escanaba, Mich	Gross	W. I. Barrows, Eng.	Add	1936	1	B	90	420	650	10.4	....	
Utah Power & Light Co., Salt Lake City, Utah	Provo	Ebasco Services, Inc.	New	1936	1	B	200	410	760	18.6	3.9	
Central Maine Power Co., Bucksport, Me	.....	.....	....	....	..	..	....	400	725	....	....	
Savannah Electric & Power Co., Savannah, Ga	Riverside	Stone & Webster	....	1936	..	..	....	400	700	....	....	
United Illuminating Co., New Haven, Conn	English Street	.....	....	....	1	..	90	400	475	....	....	
Public Service Co. of Indiana, Terre Haute, Ind	Dresser	Sargent & Lundy	Add	....	1	..	180	400	725	....	....	
Cleveland Electric Illuminating Co., Avon, Ohio	Ashtabula	.....	Add	1937	..	..	....	....	....	....	....	
Union Electric Light & Power Co., St. Louis, Mo	Cahokia	.....	....	....	5	..	260	375	740	18.0	5.3	

AL STATIONS OVER 200 LB.—Units Installed Since Jan

Heating Surface, 1,000 Sq. Ft., Each	SUPER-HEATER		FURNACE				ECONOMIZER			AIR HEATER			FORCED-DRAFT FAN				INDUCED-DRAFT FAN				Percent Makeup	Type of Firing Equipment		
	Heating Surface, 1,000 Sq. Ft.	Control	Waterwall Surface, 1,000 Sq. Ft.	Volume, 1,000 Cu. Ft.	Bottom: Dry or Slag-Tap	1,000 B.T.U. Lib., Max., Per Cu. Ft. Per Hr.	Heating Surface, 1,000 Sq. Ft.	Gas Temp. Leaving, Deg. F.	Feedwater Temp. Entering, Deg. F.	Heating Surface, 1,000 Sq. Ft.	Air Temperature Leaving, Deg. F.	Gas Temperature Leaving, Deg. F.	Number Per Boiler	Cap. Each, 1,000 C.F.M	Drive	Control	Number Per Boiler	Cap. Each, 1,000 C.F.M.	Drive	Control			1,000 B.T.U. Per Lb.	Average, % Volatile
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	P.C.	....	..
13.0	18.4	B.P.	7.2	36.4	Both	28.5	11.0	793	395	47.8	563	436	2	113.9	M.	VA.	2	236.6	T.	V.S.	2	P.C.	12.5	37
3.1	15.4	B.P.	6.8	27.8	Slag	27.0	16.3	720	399	73.6	549	337	1	185	S.C.M.	VA.	1	320	S.C.M.	V.S.-VA.	....	P.C.	14.1	16
....	....	B.P.	3.3	....	Dry	....	....	646	396	....	460	346	1	79.3	M.	V.S.	1	106.3	M.	H.C.	....	P.C.	11.6	33
....	7.4	B.P.	7.4	4.8	Slag	96.0	15.0	..	380	34.8	..	..	1	95.0	S.C.M.	VA.	1	170.0	S.C.M.	D.	....	P.C.	....	..
6.2	....	B.P.	5.3	16.1	Slag	44.6	16.7	690	425	32.7	415	430	2	86.0	M.	VA.	2	166.0	M.	VA.	1.8	P.C.	13.1	33
20.8	26.0	B.P.	20.3	41.0	Dry	29.8	51.7	710	383	45.2	562	357	2	145.0	M.	VA.	2	274.0	T.	V.S.	2	P.C.	13.5	34
7.0	14.0	B.P.	7.6	20.3	Slag	30.0	18.9	619	386	32.7	509	292	2	87.0	S.C.M.	VA.	2	139.0	S.C.M.	VA.	....	P.C.	14.2	21
4.8	7.8	B.P.	5.3	16.0	Dry	32.0	11.9	680	300	47.0	560	315	1	120.0	I.M.	VA.	1	200.0	I M.	H.C.	....	.....	14.9	22
5.1	6.2	B.P.	7.6	15.0	Slag	26.5	10.0	..	..	36.8	..	..	1	123.0	S.C.M	VA.	1	214.0	S.C.M.	H.C.	....	{P.C.-Gas-Oil}	10.3	34
5.1	7.3	B.P.	5.4	15.7	Dry	25.4	8.4	702	212	40.4	565	344	1	55.0	M.	VA.	2	93.0	M.	VA.	2	P.C.	13.8	17
4.1	10.1	I.C.	7.9	58.0	Dry	15.0	....	..	..	121.0	560	370	2	112.5	S.R M.	V.S.	2	185.0	S.R.M.	V.S.	0.8	P.C.	13.1	34
1.2	16.3	B.P.	8.1	27.3	Slag	27.3	11.5	712	390	55.0	528	353	2	102.5	S.C.M.	H.C.	2	187.5	S.C.M.	H.C.	4.5	P.C.	14.2	27
2.0	9.7	B.P.	3.5	9.4	.....	37.6	18.1	480	380	12.3	303	320	1	96.0	S.C.M.	D.	2	78.5	S.C.M.	V.S.	1.5	C.G.S.	12	34
....	....	B.P.	....	....	Dry	....	....	..	..	....	..	..	2	....	M.	.....	2	....	M.	.....	....	P.C.	....	..
6.6	19.8	B.P.	5.1	15.9	Both	34.8	12.3	642	325	56.2	486	350	1	128.0	S.C.M.	VA.	1	220.0	S.C.M.	D.	4	P.C.	10.0	35
3.4	10.8	B.P.	2.8	12.1	Dry	39.5	20.7	660	400	26.7	430	390	1	113.0	M.	H.C.-D.	1	200.0	M.	H.C.-D.	....	P.C.	13.4	35
....	....	....	....	....	.....	.....	....	....	....	....	....	....	....	....	.....	.....	....	....	.....	.....	....	.....	....	....
4.9	....	B.P.	4.0	11.7	Slag	40.0	11.9	675	380	22.2	405	420	2	112.0	M.	VA.	2	218.0	M.	H.C.	3	P.C.	13.5	36
1.9	3.9	B.P.	3.3	8.0	Slag	41.3	6.7	..	300	13.9	470	318	1	86.4	M.	VA.	1	141.0	M.	H.C.	....	P.C.	11.6	36
8.2	9.4	B.P.	5.0	28.5	.....	20.4	18.3	545	375	32.2	354	342	2	53.3	M.	V.S.	1	189.0	M.	V.S.	....	U.S.	13.2	34
6.9	10.8	B.P.	5.5	19.9	Slag	34.7	36.9	569	380	49.0	431	290	1	178.0	S.R.M.	V.S.	1	262.0	S.R.M.	V.S.	17	P.C.	14.0	17
6.2	5.4	B.P.	4.8	15.4	Dry	26.2	7.7	719	370	31.6	526	387	2	49.0	S.C.M.	VA.	2	93.0	S.C.M.	VA.	1.5	P.C.	14.0	21
....	....	....	....	....	.....	.....	....	....	....	....	....	....	....	....	.....	.....	....	....	.....	.....	....	.....	....	....
7.4	9.5	B.P.	4.1	22.0	Dry	24.5	28.5	490	300	54.1	375	300	1	130.0	S.C.M.	H.C.	1	215.0	S.C.M.	H.C.	2	P.C.	13.5	34
1.2	....	B.P.	....	4.8	Dry	37.0	....	..	..	....	..	..	1	....	M.	VA.	..	....	M.	VA.	....	Oil	18.1	..
0.8	9.3	B.P.	4.1	17.4	.....	29.1	4.0	540	385	39.2	425	280	2	59.5	S.C.M.	VA.	2	96.5	S.C.M.	VA.	3	{P.C.-Gas-Oil}	....	..
0.0	0.9	B.P.	4.0	17.5	.....	30.2	7.0	735	355	26.0	520	385	1	99.0	S.R.M.	V.S.	1	184.0	S.R.M.	V.S.	1	Oil-Gas	....	..
5.2	9.3	B.P.	4.5	22.0	Dry	25.8	23.5	662	384	22.2	436	386	2	75.0	S.C.M.	H.C.	2	137.0	S.C.M.	H.C.	....	Oil-P.C.	16.4	22
4.8	8.7	B.P.	11.0	20.0	Slag	28.4	....	..	..	32.2	540	417	2	78.0	S.R.M.	V.S.-D.	2	155.0	S.R.M.	V.S.-D.	10	P.C.	14.5	20
8.0	6.4	B.P.	3.8	13.6	Slag	33.5	9.5	543	212	14.4	363	330	1	114.0	M.	VA.	1	212.0	M.	H.C.	1.5	P.C.-Gas	10.4	34
6.5	....	....	1.8	2.9	.....	35.1	....	..	..	5.5	425	325	1	24.0	M.	V.S.	1	39.2	M.	V.S.	....	Oil-Gas	....	....
4.7	....	Des.	10.0	19.7	Dry	21.0	5.8	590	300	43.5	435	330	1	100.0	S.C.M.	H.C.	1	170.0	S.C.M.	H.C.	2	P.C.	9.8	33
....	....	....	....	....	.....	.....	....	....	....	....	....	....	1	....	.....	.....	1	....	.....	.....	....	P.C.	....	....
7.4	9.5	B.P.	4.1	22.0	Dry	24.5	28.5	490	300	54.1	375	300	1	130.0	S.C.M.	H.C.	1	215.0	S.C.M.	H.C.	2	P.C.	13.5	34
4.1	....	B.P.	6.3	19.8	Dry	22.7	....	612	370	67.7	458	323	1	105.0	S.C.M.	H.C.	1	190.0	S.C.M.	H.C.	2	P.C.	13.5	33
6.2	7.2	B.P.	4.3	....	Dry	29.6	14.1	503	300	22.5	367	299	1	75.0	S.C.M.	H.C.	1	125.0	S.C.M.	H.C.	2	P.C.	13.3	34
5.3	6.8	B.P.	2.5	12.3	Dry	25.2	14.6	520	300	26.1	365	325	1	75.0	S.C.M.	H.C.	1	125.0	S.C.M.	H.C.	2	P.C.	11.0	33
7.4	9.5	B.P.	4.1	....	Dry	24.5	28.5	490	300	54.1	375	300	1	130.0	S.C.M.	H.C.	1	215.0	S.C.M.	H.C.	2	P.C.	13.5	34
....	7.4	B.P.	7.2	4.8	Slag	82.1	15.0	..	360	34.8	..	390	1	112.0	M.	VA.	1	180.0	M.	D.	....	P.C.	13.7	35
....	....	....	....	....	.....	....	....	..	..	....	..	..	....	....	.....	.....	....	....	.....	.....	....	Oil-Gas	....	....
3.5	5.6	I.C.	6.0	18.0	Dry	16.5	....	..	..	52.3	600	350	2	37.0	S.R.M.	V.S.	2	56.5	S.R.M.	V.S.	85	P.C.	12.8	34
....	....	....	....	....	.....	....	....	..	..	....	..	..	....	....	.....	.....	....	....	.....	.....	....	.....	....	....
9.1	....	B.P.	2.6	6.2	Dry	....	....	..	..	19.4	..	..	2	40.0	M.	VA.	2	70.0	M.	H.C.	....	P.C.	....	..
6.5	1.2	....	0.6	2.1	.....	41.0	4.9	353	212	....	....	....	1	24.0	S.C.M.	VA.	1	38.6	S.C.M.	VA.	3	U.S.	14.3	23
8.8	....	B.P.	....	5.8	Dry	20.4	2.3	559	325	10.6	355	335	1	32.8	M.	VA.	1	59.0	M.	VA.	....	P.C.	13.9	23
0.8	1.0	....	....	6.2	Dry	21.5	4.0	396	212	....	..	..	1	31.0	M.	.....	1	62.5	T.	.....	6	P.C.	12.2	34
6.3	....	....	0.9	....	.....	30.3	9.1	358	212	....	....	....	....	....	.....	.....	2	64.8	M.	VA.	....	U.S.	13.7	18
9.0	....	B.P.	....	4.5	Dry	33.5	....	..	..	....	450	350	1	24.6	M.	VA.	1	44.6	S.C.M.	VA.	....	Oil	18.6	..
0.1	7.5	....	1.0	19.6	Dry	21.7	....	....	....	....	540	408	1	111.6	.....	.....	1	216.5	T.	.....	100	P.C.	10.5	34
3.6	4.5	....	7.1	7.5	Dry	34.0	4.6	725	380	20.5	476	408	1	90.0	M.	VA.	1	160.0	M.	H.C.	25–60	.....	10.4	35
0.5	....	....	5.7	8.8	.....	29.4	....	..	..	15.6	465	435	2	26.0	S.C.M.	VA.	2	46.0	S.C.M.	VA.	....	P.C.-Oil	18.5	..
6.9	8.0	B.P.	6.0	16.7	Dry	22.0	....	..	..	31.4	594	371	1	106.0	S.R.M.	V.S.	1	192.0	S.R.M.	V.S.	1	P.C.	14.1	15
3.8	2.4	B.P.	....	7.1	.....	36.0	1.5	545	375	19.6	425	280	1	62.8	S.C.M.	VA.	1	98.2	S.C.M.	VA.	3	Gas-Oil	....	..
5.3	4.5	....	4.0	13.7	Dry	20.0	20.8	335	220	....	..	..	1	69.0	S.C.M.	VA.	1	123.7	S.C.M.	VA.	....	P.C.	13.6	28
5.3	4.5	....	4.0	13.7	Dry	20.0	20.8	335	220	....	....	....	1	69.0	S.C.M.	VA.	1	123.7	S.C.M.	VA.	....	P.C.	13.6	28
9.4	....	B.P.	2.2	4.1	.....	34.2	2.4	550	340	13.0	385	325	1	141.0	M.	H.C.	1	165.0	M.	H.C.	....	T.G.S.	6.5	27
5.2	....	....	0.6	2.2	.....	31.1	....	..	..	....	..	..	1	73.0	.....	.....	..	....	.....	.....	....	Oil	18.5	..
....	....	....	....	....	.....	....	....	..	..	....	....	....	....	....	.....	.....	....	....	.....	.....	....	.....	....	....
1.1	2.8	Des.	....	5.9	Dry	26.6	....	..	..	10.3	510	381	1	35.4	S.C.M.	VA.	1	75.2	S.C.M.	VA.	....	P.C.	14.3	16
6.8	9.4	....	2.5	11.0	.....	50.4	8.5	608	330	29.0	412	360	1	101.0	M.	V.S.	1	181.0	M.	V.S.	0.7	U.S.	13.2	34
3.7	....	....	....	6.5	Dry	28.1	....	..	..	....	303	467	1	34.2	M.	.....	1	68.5	M.	H.C.	....	P.C.	11.3	33
6.7	1.2	....	1.8	3.3	Dry	25.0	....	..	..	6.6	..	385	1	32.5	M.	D.	1	21.0	M.	D.	1.5	P.C.	13.6	..
5.8	....	....	1.7	2.7	.....	29.5	....	..	..	5.2	....	....	....	....	.....	.....	....	....	.....	.....	....	P.C.-Oil	....	....
1.8	3.2	B.P.	3.3	6.8	.....	36.9	....	....	....	20.0	560	360	1	62.7	S.C.M.	VA.	1	103.6	S.C.M.	VA.	85	Oil-Gas	....	....
7.6	....	B.P.	....	8.2	.....	34.0	....	670	375	15.1	414	393	1	70.0	M.	D.	1	140.0	M.	D.	....	Oil-Gas	18.5	..
0.6	9.8	Des.	3.3	15.4	.....	32.0	8.5	..	..	27.8	..	..	2	68.5	M.	V.S.	2	165.0	M.	V.S.	....	U.S.	13.2	34
2.7	3.8	B.P.	1.6	11.0	.....	33.8	12.7	505	290	....	..	..	1	100.0	M.	.....	2	150.0	M.	.....	0.5	U.S.	13.5	27
3.5	3.8	....	2.6	13.6	.....	....	....	..	..	....	450	300	2	83.7	M.	D.-V.S.	..	125.0	M.	D.-V.S.	3-5	Gas	....	..
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	{T.G.S.	....	..
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	{.....}	....	..
9.4	6.2	B.P.	4.6	21.6	Dry	21.0	13.7	635	300	37.7	425	360	1	125.0	S.C.M.	VA.	1	200.0	M.	VA.	1.5	P.C.	11.0	36
3.5	1.5	....	1.7	6.9	Dry	34.5	....	..	..	16.0	400	350	1	....	.....	VA.	1	70.0	.....	VA.	60.0	Gas	....	..
5.0	3.1	Des.	5.9	11.7	.....	....	....	..	..	15.8	450	422	1	69.0	M.	D.-V.S.	1	114.0	M.	D.-V.S.	3.0	P.C.	14.5	25
....	....	....	....	....	.....	....	....	..	..	....	....	....	....	....	.....	.....	....	....	.....	.....	....	.....	....	....
6.2	15.3	B.P.	4.6	26.9	Slag	30.0	....	..	..	48.0	507	356	2	102.5	S.C.M.	H.C.	2	190	S.C.M.	H.C.	1.0	P.C.	14.2	27
7.7	....	....	3.7	12.3	Both	25.2	....	..	..	49.0	500	350	1	95.5	M.	D.-V.S.	1	....	M.	V.S.	1.5	P.C	9.5	30
0.4	....	Des.	1.3	6.0	Dry	20.0	4.5	350	215	....	..	..	1	33.5	M.	D.-VA.	1	67.0	M.	D	....	P.C	14.7	25
8.6	3.9	....	2.8	5.9	.....	49.4	....	..	..	....	..	..	2	90.4	M.	D.	2	102.9	M.	D.	1.0	C.G.S.	12.6	40
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	....
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	....
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	....
....	....	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	....
8.0	5.3	....	2.5	13.8	Dry	25.8	....	..	..	9.6	289	495	1	95.0	.....	.....	1	180.0	.....	VA.	....	P.C.	....	..

its Installed Since Jan. 1, 1936

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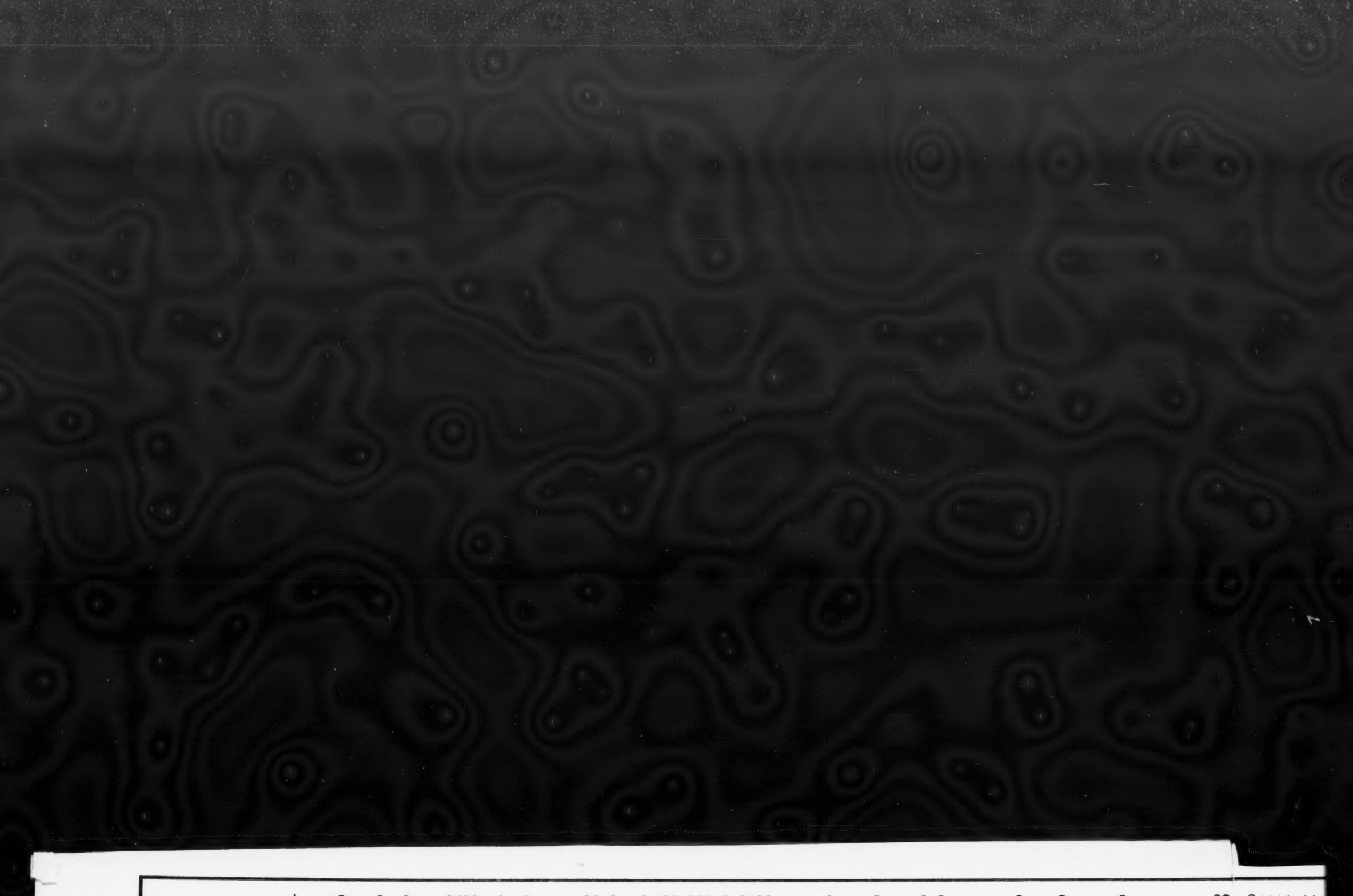
UCED-DRAFT FAN					FUEL						BOILER-FEED PUMPS			TURBINES												
Cap. Each, 1,000 C.F.M.	Drive	Control	Percent Makeup	Type of Firing Equipment	1,000 B.T.U. Per Lb.	Average, % Volatile	Average, % Ash	Average Ash-Fusing Temperature, Deg. F.	Flyash Precipitator	Average Boiler-Plant Efficiency, Percent	Number	Capacity Each, G.P.M.	Head, Lb. Per Sq. In.	Number of	Top	Speed R.P.M.	Capacity Each, 1,000 Kw.	Throttle Pressure, Lb. Per Sq. In. G.	Throttle Temp., Deg. F.	Back Pressure, Lb. Per Sq. In. ABS.	No. of Bleed Points	Bleed-Pt. Pressures, Lb. Per Sq. In. ABS.	Condenser-Tube Area, 1,000 Sq. Ft.	Generator Cooling, Air or Hydrogen	Auxiliary Power, % of Total	Yearly Plant Cap. Factor, %	B.T.U. Per Net Kw.-Hr. Station Output
..	.....	.....	....	P.C.	....	....	....	....	....	....	..	....	3,000	{ 1	....	....	22.5	2,400	}	....	..	.....	....	.....	....	....	.....
														{ 1	....	....	40.0	400	..	....	..	.....					
.6	T.	V.S.	2	P.C.	12.5	37.1	10.3	2,300	....	86	4	....	....	1	Yes	3,600	60.0	1,250	925	250	..	.....	....	Hyd.	3	....	.....
	S.C.M.	V.S.-VA.	....	P.C.	14.1	16.0	5.6	2,340	Cot.	88.7	{ 3	1,360	200	} 1	Yes	3,600	50.0	1,250	950	250	..	.....	....	Hyd.	3.8	....	11,680
.3	M.	H.C. ~	....	P.C.	11.6	33.3	10.3	2,380	....	....	3	550	1,690	1	Yes	3,600	30.0	1,250	900	0.75	..	.....	....	Hyd.	....	....	.....
.0	S.C.M.	D.	....	P.C.	....	....	....	2,600	Cot.	....	3	1,200	1,600	1	Yes	3,600	35.0	1,200	900	275	..	.....	....	Hyd.	....	....	.....
.0	M.	VA.	1.8	P.C.	13.1	33.1	11.5	2,250	Cot.	85.3	4	1,554	1,400	1	Yes	3,600	50.0	1,235	925	355	..	.....	....	Hyd.	5.0	....	12,100
.0	T.	V.S.	2	P.C.	13.5	34.2	8.7	2,500	....	....	3	1,500	....	1	Yes	3,600	40.0	1,250	925	215	..	.....	....	Hyd.	3.5	....	.....
.0	S.C.M.	VA.	....	P.C.	14.2	21.8	6.2	2,573	Cot.	89	3	1,250	1,675	2	Yes	3,600	53.0	1,200	900	215	3	5–200	....	Hyd.	10	....	11,560
.0	I M.	H.C.	....	.....	14.9	22.3	4.7	2,600	Cot.	....	4	870	1,800	1	Yes	3,600	25.0	....	..	....	..	.....	....	Air	....	....	.....
.0	S.C.M.	H.C.	....	{ P.C.-Gas-Oil }	10.3	34.0	16.0	1,900	....	....	..	....	....	1	Yes	3,600	15.0	1,250	800	325	..	.....	....	Air	....	....	.....
.0	M.	VA.	2	P.C.	13.8	17.4	8.7	2,633	Cot.	88.6	3	680	1,500	1	Yes	3,600	20.0	1,250	900	265	..	.....	....	Air	6	65	12,500
.0	S.R.M.	V.S.	0.8	P.C.	13.1	34.8	9.1	2,370	W.	86.5	3	750	1,475	1	No	1,800	80.0	1,230	825	0.55	5	5–422	52.5	Air	5.2	58	10,954
.5	S.C.M.	H.C.	4.5	P.C.	14.2	27 9	5.9	2,500	Cot.	86.5	3	1,700	1,288	1	Yes	3,600	50.0	1,250	900	245	..	.....	....	Hyd.	4.0	69	11,800
.5	S.C.M.	V.S.	1.5	C.G.S.	12	34	11.5	1,945	....	85.8	2	660	1,700	1	Yes	3,600	10.0	1,200	900	215	..	.....	....	Air	3.0	70	12,800
..	M.	.....	....	P.C.	....	....	....	.....	....	....	2	....	....	1	No	3,600	43.0	1,200	915	....	4	.....	....	Hyd.	....	....	.....
.0	S.C.M.	D.	4	P.C.	10.0	35 5	15	1,950	Cot.	86	3	1,000	1,325	1	Yes	1,500	30.0	1,200	900	235	..	.....	....	Air	....	....	12,150
.0	M.	H.C.-D.	....	P.C.	13.4	35 6	6.9	2,600	Cot.	....	3	880	1,500	1	Yes	3,600	25.0	1,200	900	250	..	.....	....	Hyd.	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	1	Yes	3,600	60.0	1,250	925	250	..	.....	....	Hyd.	....	....	.....
.6	M.	H.C.	3	P.C.	13.5	36.5	7.8	2,100	....	86	3	1,000	1,725	1	Yes	3,600	25.0	1,200	900	260	..	.....	....	Air	2.5	107	14,000
.0	M.	H.C.	....	P.C.	11.6	36.9	4.4	1,920	....	87	{ 1	550	} 1,150	1	No	3,600	20.0	825	825	0.50	5	21–291	12.6	Air	....	....	.....
											{ 2	300														
.0	M.	V.S.	....	U.S.	13.2	34	8.7	2,500	....	....	2	1,455	1,186	1	No	1,800	75.0	815	900	0.50	4	7.1–211	53.6	Air	....	....	.....
.0	S.R.M.	V.S.	17	P.C.	14.0	17.0	7.0	2,700	Cot.	89	3	1,435	1,128	2	Yes	1,500	18.75	850	800	225	..	.....	....	Air	7	31	12,800
.0	S.C.M.	VA.	1.5	P.C.	14.0	21.0	7.0	2,800	Cot.	86	3	730	1,125	1	No	3,600	30.0	800	825	0.75	4	10–196	25.0	Air	....	....	12,500
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	..	Yes	....	.....	....	....	.....	..	.....	....	.....	....	....	.....
.0	S.C.M.	H.C.	2	P.C.	13.5	34 9	7.8	2,500	F.	88.0	3	1,000	1,000	2	No	3,600	35.0	800	850	0.63	4	7–137	33.0	Hyd.	7.6	70.0	12,700
..	M.	VA.	....	Oil	18.1	.. .	....	....	....	84	3	333	955	1	Yes	3,600	6.0	850	830	225	..	.....	....	Air	....	....	.....
.5	S.C.M.	VA.	3	{ P.C.-Gas-Oil }	....	.. .	....	....	....	84	3	395	1,200	1	No	3,600	37.5	865	900	0.70	4	14.5–213	36.9	Hyd.	5.3	73.5	12,400
.0	S.R.M.	V.S.	1	Oil-Gas	....	.. .	....	....	....	82	3	750	1,100	1	No	3,600	27.5	850	900	0.75	3	11–165	30.0	Air	9.0	....	.....
.0	S.C.M.	H.C.	....	Oil-P.C.	16.4	22 4	3.5	2,300	....	86	2	1,050	1,130	1	No	3,600	40.0	850	900	0.70	3	15–206	36.0	Air	5.5	....	11,650
.0	S.R.M.	V.S.-D.	10	P.C.	14.5	20	6	2,450	Cot.	89	4	525	1,000	1	Yes	3,600	12.5	850	825	235	..	.....	....	Air	8	....	14,500
.0	M.	H.C.	1.5	P.C.-Gas	10.4	34.5	9.2	1,960	....	84.8	2	700	1,120	1	No	3,600	25.0	825	825	1.0	4	7–233	17.3	Air	5.2	75	13,000
.2	M.	V.S.	....	Oil-Gas	....	....	....	.....	....	80	2	150	1,050	1	No	3,600	6.0	825	825	1.0	4	24–315	5.4	Air	8.5	....	13,500
.0	S.C.M.	H.C.	2	P.C.	9.8	33	15.5	2,000	....	84.5	2	755	1,000	1	No	3,600	25.0	800	850	0.63	4	9–133	21.4	Air	7.6	70.0	13,350
..	.....	.....	....	P.C.	....	....	....	.....	....	....	2	....	....	2	No	3,600	35.0	800	850	0.50	..	.....	38.0	Hyd.	....	....	.....
.0	S.C.M.	H.C.	2	P.C.	13.5	34 9	7.8	2,500	F.	88.0	2	1,000	1,000	1	No	3,600	35.0	800	850	0.63	4	7–137	33.0	Hyd.	7.6	70.0	12,700
.0	S.C.M.	H.C.	2	P.C.	13.5	33.0	7.5	2,500	F.	87.0	2	860	700	1	Yes	3,600	10.0	750	850	225	..	.....	....	Air	7.5	70.0	13,750
.0	S.C.M.	H.C.	2	P.C.	13.3	34	7	2,500	F.	87.5	2	575	1,000	1	No	3,600	20.0	800	850	0.63	4	5–104	18.2	Air	7.1	70.0	13,100
.0	S.C.M.	H.C.	2	P.C.	11.0	33 0	10	2,100	F.	86.0	2	575	1,000	1	No	3,600	20.0	800	850	0.63	4	6–123	18.3	Air	7.6	70.0	13,450
.0	S.C.M.	H.C.	2	P.C.	13.5	34 9	7.8	2,500	F.	88.0	2	1,000	1,000	1	No	3,600	35.0	800	850	0.63	4	7–130	33.0	Hyd.	7.6	70.0	12,700
.0	M.	D.	....	P.C.	13.7	35.0	7.5	2,650	....	....	3	700	890	1	No	1,800	65.0	650	900	0.50	4	22–250	51.8	Hyd.	....	....	.....
..	.....	.....	....	Oil-Gas	....	....	....	.....	....	....	..	....	....	..	....	.....	.....	....	....	....	..	.....	....	.....	....	....	.....
.5	S.R.M.	V.S.	85	P.C.	12.8	34 1	8.5	2,250	....	85.7	2	490	760	1	....	3,600	13.7	600	825	35	2	75–150	2.2	Hyd.	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	1	No	1,800	35.0	650	825	0.50	3	11–150	30.0	Air	5.3	75	12,600
.0	M.	H.C.	....	P.C.	....	....	....	....	....	....	2	500	950	1	No	3,600	25.0	640	825	0.50	4	10–189	20.0	Air	....	....	.....
.6	S.C.M.	VA.	3	U.S.	14.3	23	4	2,600	Cot.	84	2	167	815	1	No	3,600	5.0	650	725	....	2	.....	4.9	Air	....	....	.....
.0	M.	VA.	....	P.C.	13.9	23.9	7.5	2,500	CY.	87.0	2	523	850	1	No	3,600	20.0	650	825	0.50	3	.....	16.9	Air	....	....	.....
.5	T.	.....	6	P.C.	12.2	34	12	2,200	....	84	{ 1	350	}	3	....	3,600	16.0	200	600	....	..	.....	28.0	Air	....	43	23,100
											{ 1	500														
.8	M.	VA.	....	U.S.	13.7	18.9	10.4	2,300	....	....	2	900	835	1	No	3,600	35.0	650	825	0.75	1	28.8	29.3	Hyd.	20	....	.....
.6	S.C.M.	VA.	....	Oil	18.6	....	....	.....	....	86	2	200	850	1	No	3,600	7.5	650	825	0.75	3	1–182	8.2	Air	....	....	.....
.5	T.	.....	100	P.C.	10.5	34	9.7	1,900	Cot.	85.4	..	....	....	1	Yes	....	12.5	625	750	260	..	.....	....	.....	....	....	.....
.0	M.	H.C.	25–60	.....	10.4	35	10	1,900	CY.	83	1	665	750	1	Yes	3,600	5.0	650	750	230	..	.....	....	Air	....	....	.....
.0	S.C.M.	VA.	....	P.C.-Oil	18.5	....	....	.....	....	86.4	2	500	900	1	No	1,800	10.0	200	540	0.50	3	.....	....	Air	10	....	20,000
.0	S.R.M.	V.S.	1	P.C.	14.1	15 3	7.5	2,550	....	86	2	1,275	870	1	No	1,800	55.0	650	825	0.75	4	4.9–190	50.0	Air	....	....	.....
.2	S.C.M.	VA.	3	Gas-Oil	....	....	....	.....	....	84	3	420	880	1	No	1,800	35.7	665	825	0.75	3	6.6–193	27.1	Air	5.6	70	13,250
.7	S.C.M.	VA.	....	P.C.	13.6	28.4	8.4	2,600	Cot.	87.2	1	730	....	1	Yes	3,600	7.5	650	750	225	..	.....	....	Air	....	....	.....
.7	S.C.M.	VA.	....	P.C.	13.6	28 4	8.4	2,600	Cot.	87.2	2	660	850	1	No	3,600	25.0	650	750	0.63	..	.....	20.5	Hyd.	....	....	.....
.0	M.	H.C.	....	T.G.S.	6.5	27	7	2,500	....	80	..	....	....	1	No	3,600	10.0	600	825	....	4	.....	8.8	.....	....	....	.....
..	.....	.....	....	Oil	18.5	....	....	.....	....	....	..	....	....	..	....	.....	.....	....	..	....	..	.....	....	.....	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	1	....	3,600	20.0	600	750	0.50	..	.....	14.0	Air	....	....	.....
.2	S.C.M.	VA.	....	P.C.	14.3	16 5	5.8	2,575	Cot.	8.6	2	580	900	1	Yes	3,600	5.0	600	..	240	..	.....	....	Air	....	....	.....
.0	M.	V.S.	0.7	U.S.	13.2	34 4	7.7	2,500	....	86	2	1,320	948	2	No	1,800	60.0	600	825	0.49	3	8.7–165	37	Air	3.9	65	12,450
.5	M.	H.C.	....	P.C.	11.3	33 9	10.5	2,040	CY.	83.6	2	130	....	1	....	3,600	10.0	455	800	0.50	3	7–133	8.6	Air	....	....	.....
.0	M	D.	1.5	P.C.	13.6	....	4.6	2,550	....	86	3	160	775	2	No	3,600	5.0	425	825	0.50	3	9–119	4.5	Air	6.0	50	14,100
..	.....	.....	....	P.C.-Oil	....	....	....	.....	....	85	..	....	....	..	....	.....	.....	....	..	....	..	.....	2.8	.....	....	....	.....
.6	S.C.M.	VA.	85	Oil-Gas	....	....	....	.....	....	83	3	600	605	1	No	3,600	5.0	465	750	45	1	190	....	Air	20	80	.....
.0	M.	D.	....	Oil-Gas	18.5	....	....	.....	....	83	2	600	450	1	No	1,800	40.0	425	725	0.75	3	7–144	30.0	Air	....	....	.....
.0	M.	V.S.	....	U.S.	13.2	34.6	11.0	2,100	....	....	1	1,800	600	1	No	1,800	60.0	400	750	0.75	3	.....	55.0	Hyd.	....	....	.....
.0	M.	.....	0.5	U.S.	13.5	27.0	7.3	2,150	....	....	{ 1	1,000	} 600	1	No	1,800	35.0	400	750	0.50	3	22–80	24.4	Air	....	....	.....
											{ 1	500														
.0	M.	D.-V.S.	3–5	Gas	....	....	....	.....	....	....	3	....	500	1	Yes	3,600	5.0	425	750	200	..	.....	....	Air	....	....	19,300
..	.....	.....	....	{ T.G.S. }	....	....	....	.....	....	....	..	....	....	..	....	.....	.....	....	..	....	..	.....	....	.....	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	..	....	.....	.....	....	..	....	..	.....	....	.....	....	....	.....
.0	M.	VA.	1.5	P.C.	11.0	36.0	10.3	1,900	Cot.	86.8	{ 1	860	} 600	1	No	1,800	25.0	450	750	0.75	4	6.8–122	27.3	Air	....	....	.....
											{ 2	430														
.0	.....	VA.	60.0	Gas	....	....	....	.....	....	82.5	2	400	600	1	....	3,600	2.0	425	725	10	..	140	....	Air	....	....	.....
.0	M.	D.-V.S.	3.0	P.C.	14.5	25	5.5	2,500	Cot.	86	{ 1	900	} 1,270	..	....	....	.....	....	..	....	..	.....	....	.....	....	....	.....
											{ 2	400														
..	S.C.M.	H.C.	1.0	P.C.	14.2	27 9	5.9	2,500	Cot.	86.2	3	....	....	1	....	1,800	75.0	400	750	0.50	3	23–171	65.0	Air	....	....	.....
..	M.	V.S.	1.5	P.C	9.5	30	5.4	2,090	....	82.6	1	1,250	450	1	No	3,600	25.0	350	750	0.50	5	2.5–114	30.0	Air	5.0	58	18,000
.0	M.	D	....	P.C	14.7	23	4.5	2,800	....	85.0	1	300	500	1	....	3,600	1.5	420	650	195	2	195	....	Air	1.5	....	.....
.9	M.	D.	1.0	C.G.S.	12.6	40.4	5.6	1,925	....	72	2	500	540	1	No	1,800	18.75	400	750	0.74	3	5.6–143	16.3	Air	6.2	....	15,800
..	.....	.....	....	.....	....	....	....	.....	....	....	2	350	....	1	....	....	5.0	.....	..	55	1	155	....	.....	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	1	....	....	7.5	380	700	....	2	30–140	7.8	Air	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	..	No	....	.....	....	..	....	..	.....	....	.....	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	..	No	....	.....	....	..	....	..	.....	....	.....	....	....	.....
..	.....	.....	....	.....	....	....	....	.....	....	....	..	....	....	1	No	1,800	50.0	375	700	1.0	2	20–34	42.0	Air	4.4	....	.....
.0	.....	VA.	....	P.C.	....	....	....	2,025	....	....	2	1,800	450	..	....	1,800	75.0	....	..	....	..	.....	....	Hyd.	....	....	.....



Name of Company and Location	Consulting Engineers	New, Addition or Replacement	First Operation, New Units	BOILERS: Number	BOILERS: Straight- or Bent-Tube	BOILERS: Max. Cap. Each, 1,000 Lb. per Hr.	BOILERS: Gage Pressure, Lb. Per Sq. In.	BOILERS: Steam Temp., Deg. F.	BOILERS: Heating Surface, 1,000 Sq. Ft., Each	SUPE HEAT: Heating Surface, 1,000 Sq. Ft.	
Utah Power & Light Co., Salt Lake City, Utah	Provo	Ebasco Services, Inc.	New	1936	1	B	200	410	760	18.6	3.9	....	2.
Central Maine Power Co., Bucksport, Me.	....	....	....	..	..	....	....	400	725	....	....	....	..
Savannah Electric & Power Co., Savannah, Ga.	Riverside	Stone & Webster	....	1936	..	..	....	400	700	....	....	....	..
United Illuminating Co., New Haven, Conn.	English Street	....	....	....	1	..	90	400	475	....	....	....	..
Public Service Co. of Indiana, Terre Haute, Ind.	Dresser	Sargent & Lundy	Add	....	1	..	180	400	725	....	....	....	..
Cleveland Electric Illuminating Co., Avon, Ohio	Ashtabula	....	Add	1937	..	..	....	....	..	....	....	....	..
Union Electric Light & Power Co., St. Louis, Mo.	Cahokia	....	....	....	5	..	260	375	740	18.0	5.3	....	2
Municipal Plants:													
Board of Water & Electric Light Comm., Lansing, Mich.	Ottawa Street	Burns & Roe Inc	New	1938	2	S	225	925	900	2.8	7.0	B.P.	3.
Municipal Electric & Water Dept., Winnetka, Ill.	....	Sargent & Lundy	Add	1937	2	..	40	475	775	5.0	....	....	..
Dept. of Water, Light & Power, Kansas City, Kan.	Quindaro	Burns & McDonnell	Add	1938	1	B	180	450	750	16.3	....	....	1
Rocky Mt. Public Utilities, Rocky Mt., N. C.	....	Burns & McDonnell	....	....	1	..	100	450	725	10.5	....	....	0
City Water Lt. & Pr. Dept., Springfield, Ill.	Lakeside	Burns & McDonnell	New	1936	1	S	112	450	714	9.2	2.8	....	1
Municipal Electric Light Plant, Vineland, N. J.	....	Scofield Engrg. Co.	....	1936	1	..	96	450	750	7.9	....	....	0.
Regina Light & Power Dept., Saskatchewan, Can.	....	....	Add	1937	1	B	150	450	825	15.0	3.1	Des.	..
Municipal Light & Power Plant, Ames, Ia.	....	....	Add	1938	2	B	40	450	750	3.8	1.0	....	0.
City of Ft. Collins, Fort Collins, Colo.	....	Burns & McDonnell	New	1936	2	B	25	425	700	4.0	....	....	0.
Municipal Utilities, Marshall, Mo.	....	Henrici-Lowry Eng. Co.	Add	1937	1	S	24	425	725	3.3	0.8	....	0.
Raton Public Service Co., Raton, N. M.	....	E. Weber	....	1937	1	B	25	425	750	....	....	....	..
Board of Water & Light Comm., Austin, Minn.	....	R. D. Thomas & Assoc.	Add	1937	1	B	80	425	750	9.6	3.9	....	1
Marshfield Water, El. Lt. & Pr. Co., Marshfield, Wis.	....	....	....	....	1	..	40	400	650	6.2	....	....	0
Rock Rapids Municipal Power, Rock Rapids, Ia.	....	....	....	....	2	..	16	400	700	3.1	....	....	0.
Greenwood Light & Power Plant, Greenwood, Miss.	....	....	....	....	..	..	....	....	..	....	....	....	..

INSTITUTIO

Name of Company and Location	Consulting Engineers	New, Addition or Replacement	First Operation, New Units	BOILERS: Number	BOILERS: Straight- or Bent-Tube	BOILERS: Max. Cap. Each, 1,000 Lb. per Hr.	BOILERS: Gage Pressure, Lb. Per Sq. In.	BOILERS: Steam Temp., Deg. F.	BOILERS: Heating Surface, 1,000 Sq. Ft., Each	SUPE HEAT: Heating Surface, 1,000 Sq. Ft.	
R. I. State Hospital, Howard, R. I.	Jenks & Ballou	New	1937	2	B	60	400	600	6.1	....	
University of Minnesota, Minneapolis, Minn.	W. F. Holman	Add	1937	1	B	125	315	625	8.5	....	
Wallum Lake Sanitarium, Wallum Lake, R. I.	....	Add	1937	1	B	15	....	....	2.5	...	
				1	B	10	250	487	1.8		
Missouri State Sanitarium, Mt. Vernon, Mo.	R. Teensfeldt / Baumes-McDevitt	....	1937	2	....	11.7	250	....	....	....	
Anchor Hospital, St. Paul, Minn	....	....	....	1	....	....	250	....	3.7	....	
Boston City Hospital, Boston, Mass.	....	....	....	1	....	42	225	500	6.0	....	
State School For Feeble Minded, Redfield, S. D.	D. Radsliff	Add	1937	1	B	30	200	Sat.	3.8	....	
Minnesota State Hospital, Mooselake, Minn.	Rose & Harris	....	1937	3	B	....	200	Sat.	....	....	
Dept. Sanitation, New York, N. Y.	....	New	1936	2	B	12	200	490	2.6	0.15	
University of Texas, Austin, Tex.	....	Add	1936	1	S	60	200	500	6.1	0.7	
Illinois School for Boys, St. Charles, Ill.	....	Add	1936	1	S	27	200	....	4.0	....	
University of Oklahoma, Norman, Okla	....	Add	1937	3	S	50	200	538	6.0	1.6	
U. S. Picatinny Arsenal, Dover, N. J.	....	....	1937	2	B	70	450	600	7.3	....	
U. S. Naval Air Station, Pensacola, Fla.	....	Add	1937	1	B	35	250	605	4.0	1.0	

LIST OF ABBREVIATIONS

A.S. — Acid sludge
B. — Bent-tube
B.E.T. — Backpress.extrac. turb.
B.F.G. — Blast-furnace gas
B.P. — Bypass
B.P.T. — Backpressure turb.
C.E.T. — Cond. extrac. turb.
C.G.S. — Chain-grate stoker
C.T. — Condensing turbine
CY. — Cyclone
D. — Damper
Des. — Desuperheater
Eng. — Steam engine
F. — Fan
G.E. — Gas engine
H. — Hand firing
H.C. — Hydraulic coupling
H.S. — Hand stoker
I.C. — Inherent control

9	....	2.8	5.9	.....	49.4	....	..	..	....	..	..	2	90.4	M.	D.	2	102.9	M.	D.	1.0	C.G.S.	12.6	40
	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	..
	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	..
	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	..
3	....	2.5	13.8	Dry	25.8	....	..	..	9.6	289	495	2	95.0	.....	.....	1	180.0	.....	VA.	....	P.C.	....	..
0	B.P.	3.2	8.2	Slag	32.2	6.8	750	439	42.8	648	325	2	35.0	M.	H.C.	2	115.0	M.	H.C.	1.5	P.C.	13.2	37
	....	....	....	.....	....	....	..	..	3.4	..	..	1	....	.....	.....	1	....	.....	.....	....	C.G.S.	....	..
	....	1.9	11.2	Slag	22.4	1.8	580	225	19.6	360	350	1	67.6	S.C.M.	H.C.	1	109.0	S.C.M.	H.C.	....	P.C.	12.0	37
	....	0.6	3.0	.....	....	....	..	..	....	..	..	1	45.0	.....	.....	..	....	.....	.....	....	.....	....	..
8	....	1.6	7.2	Dry	....	....	..	..	12.0	350	270	1	39.1	S.C.M.	H.C.	1	72.0	S.C.M.	H.C.	1.0	P.C.	10.2	40
	....	0.28	....	.....	....	....	..	..	4.5	..	..	1	32.3	.....	H.C.	1	74.5	.....	.....	....	U.S.	....	..
i	Des.	....	11.3	Dry	19.7	....	..	..	23.5	530	395	1	45.7	M.-T.	V.S.	1	88.5	M.-T.	V.S.	....	Oil-P.C.	12.0	24
0	....	0.26	....	.....	40.4	3.8	411	290	....	..	..	1	18.0	S.C.M.	D.	1	22.0	M.	V.S.	....	C.G.S.	9.2	32
.	....	0.18	1.5	.....	33.5	....	..	..	....	..	..	1	20.5	S.C.M.	VA.	1	39.0	S.C.M.	H.C.	....	S.S.	9.3	30
8	....	0.05	....	.....	38.0	....	..	..	....	..	..	1	....	M.	H.C.	1	....	M.	H.C.	2.0	C.G.S.	12.9	35
.	....	....	....	.....	....	....	..	..	....	..	..	1	....	M.	.....	1	....	M.	.....	....	S.S	....	..
9	....	1.6	4.0	.....	34.6	....	..	..	11.4	460	370	1	30.0	T.	V.S.	1	40.0	T.	V.S.	20–90	U.S.W. Gas-Oil	11.5	33
.	....	0.3	....	.....	....	....	..	..	....	..	..	1	18.0	.....	.....	..	....	.....	.....	....	U.S.	....	..
.	....	0.08	....	.....	....	....	..	..	....	..	..	2	....	.....	.....	..	....	.....	.....	....	S.S.	....	..
.	....	....	....	.....	....	....	..	..	....	..	..	..	....	.....	.....	..	....	.....	.....	....	.....	....	..

STITUTIONAL PLANTS (INCL. GOVERNMENT) 200 LB. AND OVER—Units Installed Since Jan. 1, 1936

	SUPER-HEATER		FURNACE				ECONOMIZER			AIR HEATER			FORCED-DRAFT FAN				INDUCED-DRAFT FAN					
Heating Surface, 1,000 Sq. Ft., Each	Heating Surface, 1,000 Sq. Ft.	Control	Waterwall Surface, 1,000 Sq. Ft.	Volume, 1,000 Cu. Ft.	Bottom: Dry or Slag-Tap	1,000 B.T.U. Lib. Max., Per Cu. Ft. Per Hr.	Heating Surface, 1,000 Sq. Ft.	Gas Temp., Leaving, Deg. F.	Feedwater Temp. Entering, Deg. F.	Heating Surface, 1,000 Sq. Ft.	Air Temp. Leaving, Deg. F.	Gas Temp. Leaving, Deg. F.	Number Per Boiler	Capacity Each, 1,000 C. F. M.	Drive	Control	Number Per Boiler	Capacity Each, 1,000 C. F. M.	Drive	Control	Percent Makeup	Type of Firing
6.1	....	....	1.9	2.8	....	25.7	....	....	....	5.0	....	....	1	17.0	T.	.....	1	26.0	T.	.....	....	Oil
8.5	....	....	4.5	7.0	Dry	17.0	....	....	....	8.5	353	407	1	30.0	T.	V. S.	1	59.3	T.	V. S.	10	P. C
2.5	...	Des.	....	....	....	....	....	....	....	....	250	....	....	....	....	.....	....	.....	....	.....	....	Oil
1.8																						
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	....	.....	....	.....	....	....
3.7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	....	.....	....	.....	....	P. C
6.0	....	....	....	2.4	....	....	....	....	....	....	....	....	....	....	....	.....	....	.....	....	.....	....	Oil
3.8	....	....	....	0.9	....	64.0	....	....	....	....	....	....	1	19.0	M.	.....	....	.....	....	.....	70	St.
....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	M.	.....	....	33.0	T.	.....	....	U. S
2.6	0.15	....	....	0.8	Dry	35.0	....	....	....	0.8	150	390	1	11.0	M.	.....	1	33.0	T.	.....	....	Ref
6.1	0.7	....	....	1.4	Dry	62	....	....	....	3.8	300	425	1	16.5	M.	.....	1	33.2	M.	.....	....	T. C
4.0	....	....	....	1.5	....	....	....	....	....	....	....	....	1	10.0	M.	.....	....	.....	....	.....	....	S. S
6.0	1.6	....	....	4.0	....	15.0	....	....	....	2.6	270	290	....	....	....	.....	....	.....	....	.....	2	Gas
7.3	....	....	0.6	3.4	....	26	....	....	....	....	....	....	1	35.0	M.-T.	VA.-V.S.	1	140.0	M.	.....	50–75	U. S
4.0	1.0	....	....	1.0	....	33.3	....	....	....	....	....	....	1	13.5	M.	H. C.	1	40.0	M.	H. C.	....	N. C

g
coupling
er
control

I.M. — Induction motor
Liq. — Liquor
M. — Motor
M.P.T. — Mixed press. turb.

N.G. — Natural gas
O.S. — Overfeed stoker
P.C. — Pulverized coal
Ref. — Refuse

S. — Straight tube
S.C.M. — Squirrel-cage motor
S.M. — Synchronous motor
S.R.M. — Slip-ring motor

S.S. — Sprinkler stoker
St. — Stoker
T. — Turbine
T.B. — Turbo blowers

T.G.S. — Trav.-gr
U.S. — Underfe
U.S.W. — Underfe
waterc

	D.	1.0	C.G.S.	12.6	40.4	5.6	1,925	....	72	2	500	540	1	No	1,800	18.75	400	750	0.74	3	5.6–143	16.3	Air	6.2	....	15,800
...	.....	....	.....	....	....	....	....	....	....	2	350	....	1	....	....	5.0	....	..	55	1	155	....	.....	....	....	.....
...	.....	....	.....	....	....	....	....	....	....	..	....	....	1	....	....	7.5	380	700	....	2	30–140	7.8	Air	....	....	.....
...	.....	....	.....	....	....	....	....	....	....	..	....	....	..	No	....	.....	....	..	....	..	.....	....	.....	....	....	.....
...	.....	....	.....	....	....	....	....	....	....	..	....	....	..	No	....	.....	....	..	....	..	.....	....	.....	....	....	.....
...	.....	....	.....	....	....	....	....	....	....	..	....	....	1	No	1,800	50.0	375	700	1.0	2	20–34	42.0	Air	4.4	....	.....
...	VA.	....	P.C.	....	....	....	2,025	....	....	2	1,800	450	..	....	1,800	75.0	....	..	....	..	.....	....	Hyd.	....	....	.....
	H.C.	1.5	P.C.	13.2	37.5	7.5	2,450	Cot.	88.2	4	300	1,065	1	No	3,600	25.0	825	900	0.50	6	23–536	23.0	Hyd.	....	....	.....
													1	....	3,600	4.0	825	900	224	..	.....	....	Air			
													1	No	3,600	2.5	175	Sat.	15	..	.....	....	Air			
...	.....	....	C.G.S.	....	....	....	....	....	....	..	....	....	1	....	3,600	3.0	425	725	0.50	..	.....	....	.....	....	....	.....
M.	H.C.	....	P.C.	12.0	37.9	15.5	....	....	....	2	800	500	1	No	1,800	30.0	400	725	0.75	3	.....	40.0	Air	....	....	.....
...	.....	....	.....	....	....	....	....	....	....	..	....	....	..	....	....	.....	....	....	....	..	.....	....	.....	....	....	.....
M.	H.C.	1.0	P.C.	10.2	40	15	2,000	....	81	3	250	530	1	No	3,600	10.0	400	700	0.75	3	6.7–115	16.0	Air	7	50	15,000
...	.....	....	U.S.	....	....	....	....	....	....	2	300	....	1	No	....	4.0	400	700	....	2	50–140	5.0	.....	....	....	.....
T.	V.S.	....	Oil-P.C.	12.0	24	16	2,200	....	85.4	..	....	....	1	No	3,600	15.0	400	800	0.50	2	15.5–57	19.7	Air	4.3	50	13,250
	V.S.	....	C.G.S.	9.2	32.5	18.8	1,950	....	79.3	..	....	....	..	....	....	.....	....	....	.....	..	.....	.....	.....	....	....	.....
M.	H.C.	....	S.S.	9.3	30.8	5.8	....	....	....	3	50	500	2	No	3,600	1.5	400	700	0.5	2	.....	2.3	Air	....	....	.....
	H.C.	2.0	C.G.S.	12.9	35	12	2,000	....	....	1	45	550	1	No	3,600	1.5	400	700	1.2	2	28–94	2.5	Air	3.4	..	.....
	.....	....	S.S	....	....	....	....	....	....	2	....	....	..	....	....	.....	....	..	....	..	.....	....	.....	....	....	.....
	V.S.	20–90	U.S.W. Gas-Oil	11.5	33.5	12	2,000	....	85.4	..	....	....	..	....	....	.....	....	..	....	..	.....	....	.....	....	....	.....
...	.....	....	U.S.	....	....	....	....	....	....	2	100	....	1	....	....	2.5	....	..	....	..	.....	2.9	.....	....	....	.....
...	.....	....	S.S.	....	....	....	....	....	....	2	....	....	1	....	....	0.50	....	..	....	1	25	1.2	.....	....	....	.....
													1	....	....	0.35	....	..	....	1	25					
...	.....	....	.....	....	....	....	....	....	....	..	....	....	1	....	3,600	3.5	400	598	1.0	..	.....	4.4	.....	....	....	.....

Installed Since Jan. 1, 1936

INDUCED-DRAFT FAN					FUEL							BOILER-FEED PUMPS			GENERATING UNITS										
Number Per Boiler	Capacity Each, 1,000 C. F. M.	Drive	Control	Percent Makeup	Type of Firing Equipment	1,000 B.T.U. Per Lb.	Average % Volatile	Average % Ash	Average Ash-Fusing Temp., Deg. F.	Fly-Ash Precipitator	Average Boiler Plant Eff., %	Number	Capacity Each, G.P.M.	Head, Lb. Per Sq. In.	Power Unit Type	Number	Top	Power Unit Speed, R. P. M.	Capacity Each, 1,000 KW.	Throttle Pressure, Lb. Per Sq. In. Ga.	Throttle Temp., Deg. F.	Extraction Press., Lb. Per Sq. In. G.	Exhaust Press., Lb. Per Sq. In. A.B.S.	Condenser Tube Area, 1,000 Sq. Ft.
1	26.0	T.	.....	....	Oil	....	....	....	....	....	....	3	150	475	B.E.T.	2	No	3,600	0.75	375	600	100	20	.....
1	59.3	T.	V. S.	10	P. C.	12.3	34.5	7.7	2450	....	84.9	3	600	160	.....	....	....	.....	.....	....	....	.....	....	.....
....	.....	....	.....	....	Oil	....	....	....	....	....	....	2	600	600	B.E.T.	2	No	4,289	0.20	200	460	40	20	.....
....	.....	....	.....	....	.....	....	....	....	....	....	....	....	....	...	Eng.	1	....	.....	0.20	160	....	.....	19	.....
															Eng.	2	....	.....	0.15					
....	.....	....	.....	....	P. C.	....	....	....	....	....	....	....	....	....	Eng.	3	....	.....	0.45	....	....	.....	....	.....
....	.....	....	.....	....	Oil	....	....	....	....	....	....	1	415	....	B.P.T.	1	....	.....	0.60	....	....	.....	....	.....
....	.....	....	.....	70	St.	7	30	7	....	.....	60	1	160	210	Eng.	3	....	.....	0.52 (tot.)	130	Sat.	.....	18	.....
....	.....	....	.....	....	U. S.	....	....	....	....	....	....	2	....	....	Eng.	2	No	.....	0.20	165	....	.....	20	.....
1	33.0	T.	.....	....	Ref.-Oil	7.7	20	10–15	1800	....	....	2	30	....	B.P.T.	2	No	5,000	0.20	200	490	.....	20	.....
1	33.2	M.	.....	....	T. G. S.	7.4	28	8.5	2300	....	76	1	250	300	C.E.T.	1	No	3,600	2.5	200	488	50	1.0	3.5
....	.....	....	.....	....	S. S.	....	....	....	....	....	....	2	175	130	Eng.	2	....	300	.....	120	Sat.	.....	17	.....
....	.....	....	.....	2	Gas	....	....	....	....	....	80.5	1	200	225	C.E.T.	1	No	3,600	0.625	200	520	1	1.0	1.3
1	140.0	M.	.....	50–75	U. S.	14	21–29	7–10	2500	....	....	3	200	525	B.E.T.	1	....	.....	1.5	....	....	125–	....	.....
															B.E.T.	1	....	.....	0.6	....	....	90	....	.....
															C.T.	1	....	3,600	0.75	425	600	.....	....	1.7
1	40.0	M.	H. C.	....	N. G.	....	....	....	....	....	80	....	....	....	C.E.T.	2	No	3,600	1.25	240	600	50	20	2

— Sprinkler stoker
— Stoker
— Turbine
— Turbo blowers

T.G.S. — Trav.-grate stoker
U.S. — Underfeed stoker
U.S.W. — Underfeed stoker watercooled

Va. — Vane
V.S. — Variable-speed
W. — Wet
W.G. — Waste gas

Under bleed points, only the lowest and highest pressures are listed.

NOTE — Because of interest, the Port Washington station of Milwaukee Elec. R. R. Co. and Richmond station of Philadelphia Elec. Co. are included, although installed previous to 1936.